Bone-anchored prostheses from rehabilitation and beyond: is what you see is what you get?

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Bio

Dr Laurent Frossard is currently an Adjunct Professor at the Queensland University of Technology (QUT) and University of Sunshine Coast (USC) as well as the Director/Chief Scientist Officer at YourResearchProject.

He is a Biomechanist focusing on the locomotion and rehabilitation of individuals with lower limb loss. He is one of the very few independent experts in the clinical benefits of bone-anchored prostheses.

His academic track record includes over 130 publications, several grants, supervisions of students and international collaborations (www.LaurentFrossard.com).

Presentation Synopsis

Individuals with limb amputation fitted with conventional socket-suspended prostheses often experience socket-related discomfort leading to a significant decrease in quality of life.[1-3]

Bone-anchored prostheses are increasingly acknowledged as viable alternative method of attachment of artificial limb.[4-8] In this case, the prosthesis is attached directly to the residual skeleton through a percutaneous fixation.[5, 9-12]

To date, a few osseointegrated devices are commercially available, relying either on screw-type fixations or press-fit implants.[4, 5, 9, 10, 13-27] Several devices are at different stages of development particularly in Europe and the US.[12, 18, 21, 26-43] Clearly, surgical procedures are currently blooming worldwide. Indeed, Australia is one of the fastest growing populations worldwide.

Previous studies about bone-anchored prostheses have focused on fragmented surgical and biomechanics aspects as well as specific clinical benefits and safety of the procedure.[6, 7, 13-15, 17, 19, 40, 44-87]

However, very few publications have synthetized this information and provided an overview of the current international developments in bone-anchored prostheses.

The purpose of the presentation will be to provide an overview of the state-of-art developments in bone-anchored prostheses with as strong emphasis on various treatments (e.g., design of fixations, surgical procedures), rehabilitation programs and the outcomes (e.g., benefits, harms).

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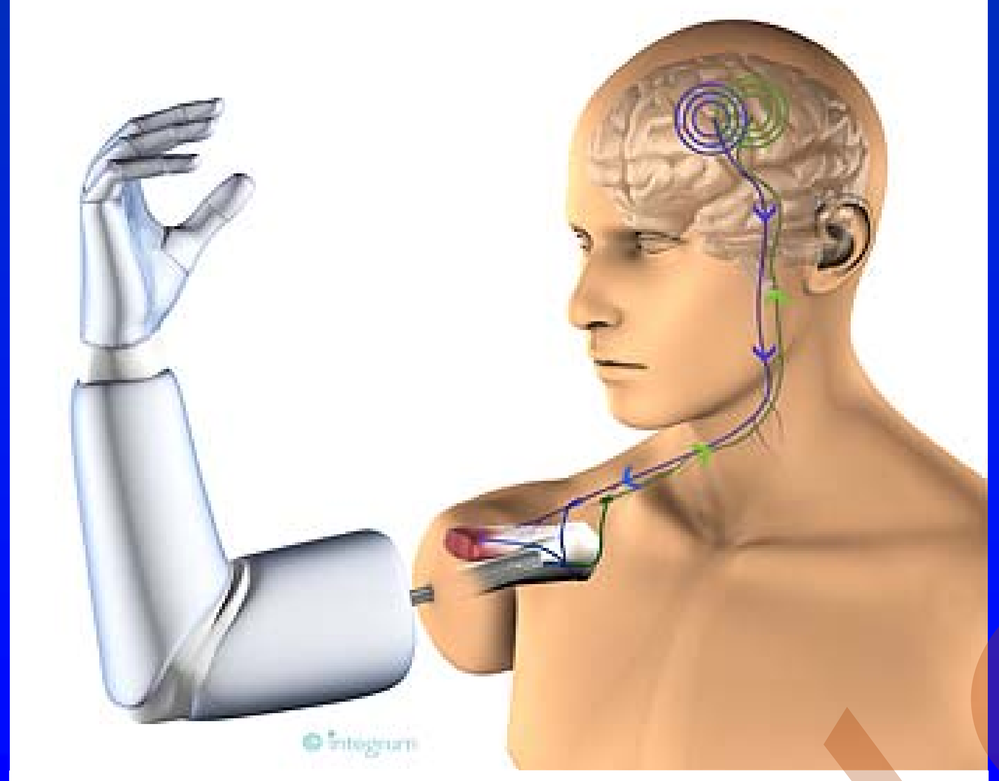
Bone-anchored prostheses from rehabilitation and beyond: is what you see is what you get?



http://www.chalmers.se/en/news/Pages/Thought-controlled-prosthesis-is-changing-the-lives-of-amputees.aspx

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Rehabilitation Medicine Society of Australia and New Zealand

1st Annual Scientific Meeting

19 October 2016

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Disclosure

Conflict

- No conflicts of interest
- No financial benefits associated with BAP
- No financial benefits associated with treatments
- Done some research work for:
  - Sahlgrenska University Hospital, Sweden
  - Ghent University Hospital, Belgium
- Done some consulting work for:
  - Munjed Al Muderis – Orthopeadic Surgery
  - University of the Sunshine Coast

Bone-anchored prostheses from rehabilitation and beyond: is what you see is what you get?

Background

Attachment

Prosthetic attachment options

Example: Young active trauma

http://www.burgalaw.com/practice-areas/rancho-cucamonga-personal-injury-attorney/

Background

Attachment

Socket

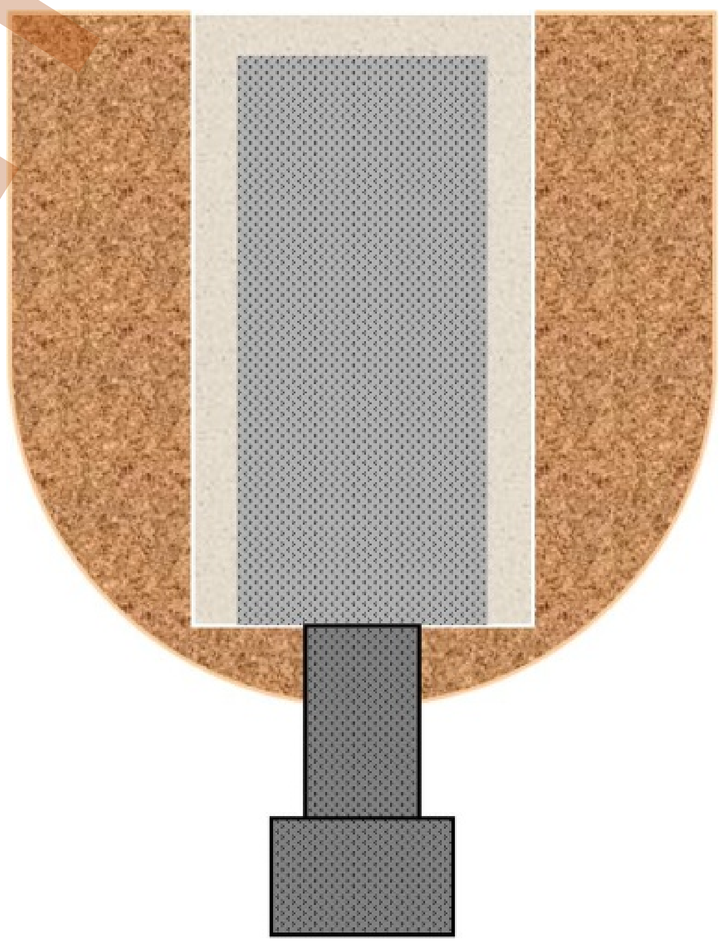
http://www.laurentfrossard.com/biomechanics-of-individuals-with-limb-loss/population

Background

Attachment

Socket

BAP



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Background

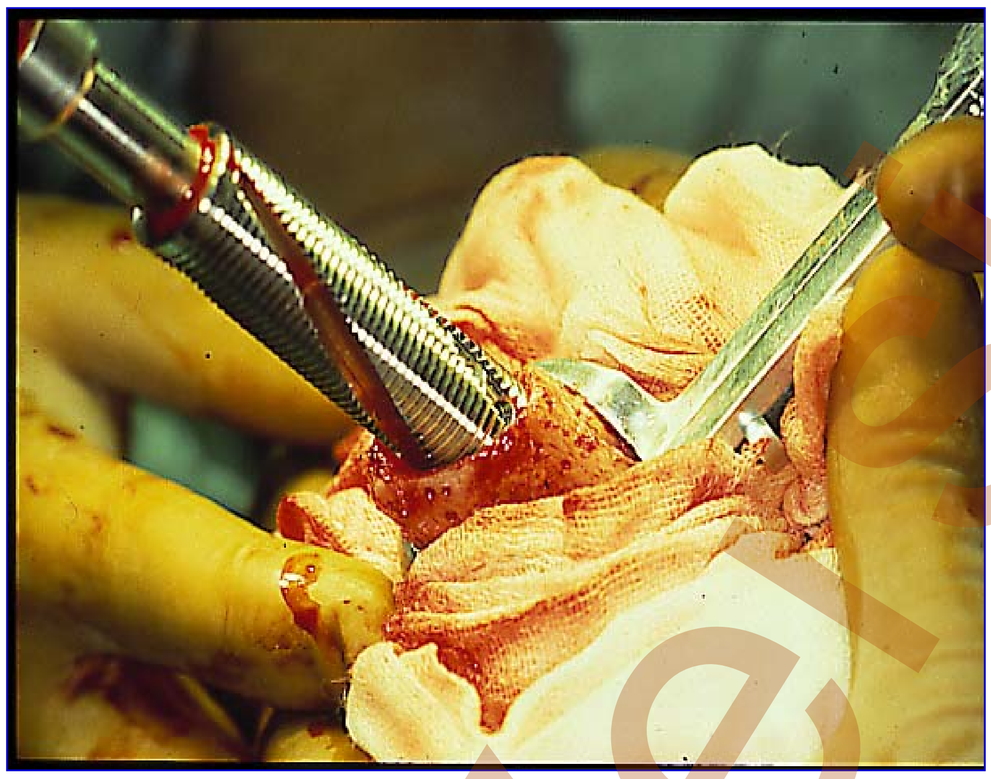
Attachment

Socket

BAP

Screw-type

Osseointegrated Prosthesis for Rehabilitation of Amputees, (OPRA), Integrum Ab, Sweden



Dr Rickard Branemark

http://opraosseointegration.com/

Background

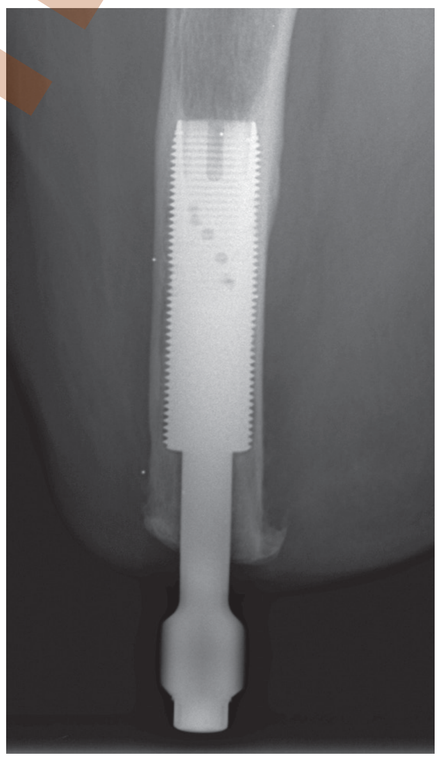
Attachment

Socket

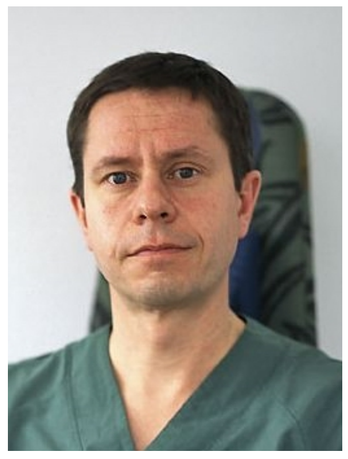
BAP

Screw-type

Osseointegrated Prosthesis for Rehabilitation of Amputees, (OPRA), Integrum Ab, Sweden



Dr Rickard Branemark



Nebergall, A., C. Bragdon, A. Antonellis, J. Kärrholm, R. Brånemark, and H. Malchau, Stable fixation of an osseointegated implant system for above-the-knee amputees. Acta Orthopaedica, 2012. 83(2): p. 121-128

Background

Attachment

Socket

BAP

Screw-type

Osseointegrated Prosthesis for Rehabilitation of Amputees, (OPRA), Integrum Ab, Sweden

Dr Rickard Branemark

http://www.laurentfrossard.com/biomechanics-of-individuals-with-limb-loss/population

Background

Attachment

Socket

BAP

Screw-type

Press-fit

Integral Leg Prosthesis (ILP), Orthodynamics Pty Ltd, UK

Dr Horst Aschoff

Lunow, C., K. Staubach, and H. Aschoff, [Endo-exo Femoral Prosthesis]. Zeitschrift Der Unfallchirug, 2010.

Background

Attachment

Socket

BAP

Screw-typ

Press-fit

Integral Leg Prosthesis (ILP), Orthodynamics Pty Ltd, UK

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Background

Attachment

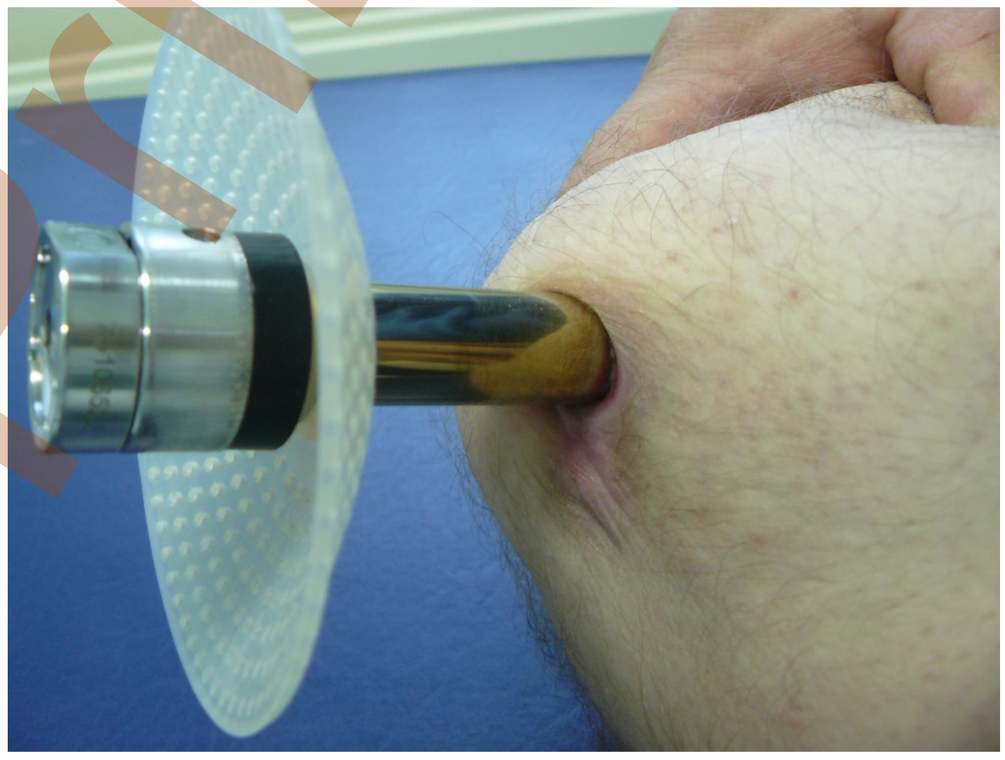
Socket

BAP

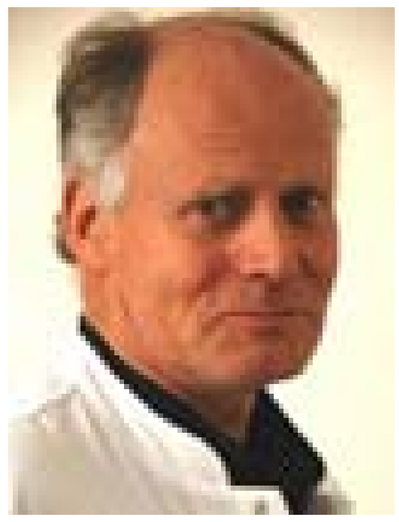
Screw-typ

Press-fit

Integral Leg Prosthesis (ILP), Orthodynamics Pty Ltd, UK



Dr Horst Aschoff



Source: Unknown

Background

Attachment

Socket

BAP

Screw-typ

Press-fit

Osseointegrated Prosthesis Limb (OPL) Permedica, Italy

Dr Munjed Al Muderis

http://www.osseointegrationaustralia.com.au/

Background

Attachment

Socket

BAP

Screw-typ

Press-fit

Osseointegrated Prosthesis Limb (OPL) Permedica, Italy

Dr Munjed Al Muderis

Al Muderis, M., K. Tetsworth, A. Khemka, S. Wilmot, B. Bosley, S.J. Lord, and V. Glatt, The Osseointegration Group of Australia Accelerated Protocol (OGAAP-1) for two-stage osseointegrated reconstruction of amputated limbs. Bone & Joint Journal, 2016. 98-B(7): p. 952-960.

Background

Attachment

Socket

BAP

Screw-typ

Press-fit

	ILP	OPL	OPRA
Interface fixation - bone	Press-fit	Press-fit	Screw

Background

Attachment

Socket

BAP

Screw-typ

Press-fit

	ILP	OPL	OPRA
Interface fixation - bone	Press-fit	Press-fit	Screw
Nb of surgeries	2	2	2

Stage 1 **Stage 2**

Background

Attachment

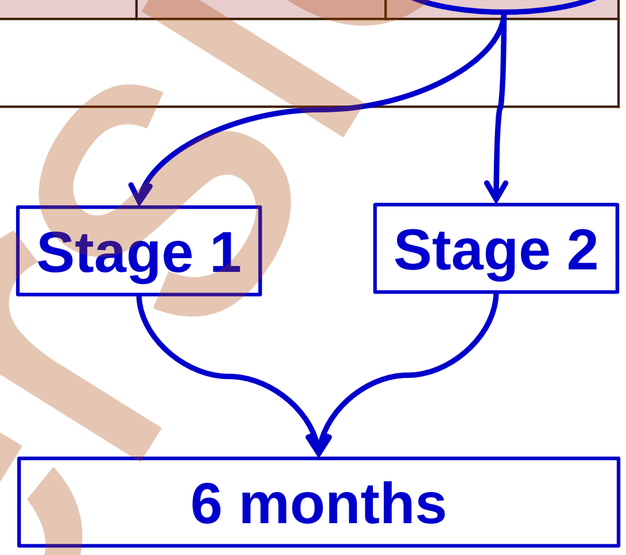
Socket

BAP

Screw-typ

Press-fit

	ILP	OPL	OPRA
Interface fixation - bone	Press-fit	Press-fit	Screw
Nb of surgeries	2	2	2
Duration rehabilitation *	4 mth	4 mth	9-12 mth
* Estimation			



Background

Attachment

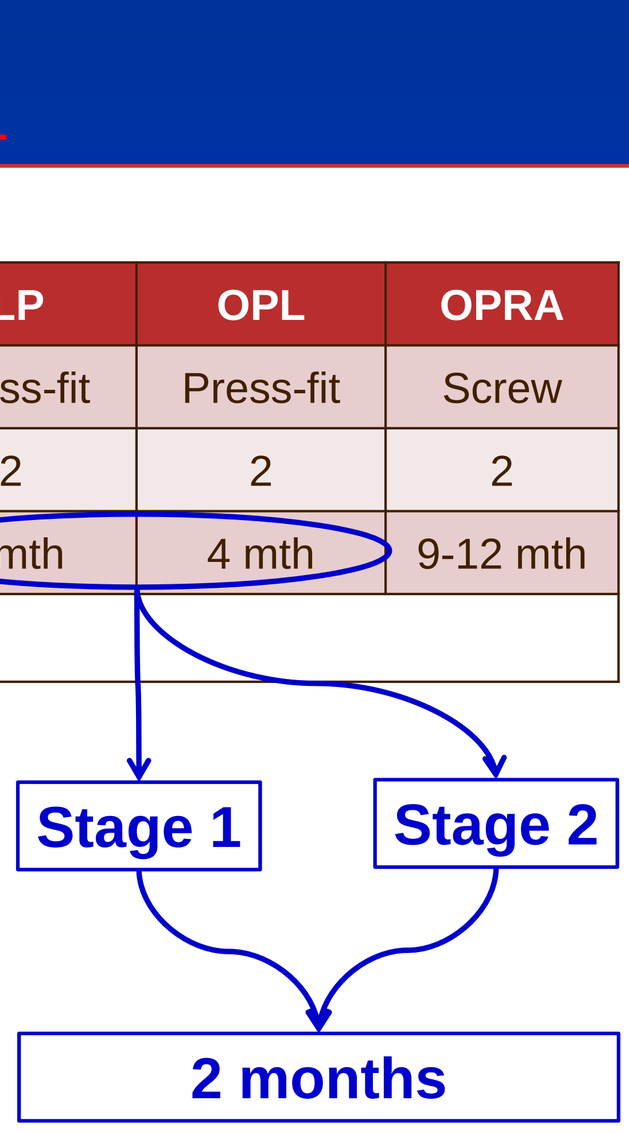
Socket

BAP

Screw-typ

Press-fit

	ILP	OPL	OPRA
Interface fixation - bone	Press-fit	Press-fit	Screw
Nb of surgeries	2	2	2
Duration rehabilitation *	4 mth	4 mth	9-12 mth
* Estimation			



Background

Attachment

Socket

BAP

Screw-typ

Press-fit

	ILP	OPL	OPRA
Interface fixation - bone	Press-fit	Press-fit	Screw
Nb of surgeries	1	2	2
Duration rehabilitation *	0	4 mth	9-12 mth
* Estimation			

Stage 1

Background

Attachment

Socket

BAP

Screw-typ

Press-fit

	ILP	OPL	OPRA
Interface fixation - bone	Press-fit	Press-fit	Screw
Nb of surgeries	2	2	2
Duration rehabilitation *	4 mth	4 mth	9-12 mth
Nb of years since first S1 *	10	4	17
* Estimation			

Background

Attachment

Socket

BAP

Screw-typ

Press-fit

	ILP	OPL	OPRA
Interface fixation - bone	Press-fit	Press-fit	Screw
Nb of surgeries	2	2	2
Duration rehabilitation *	4 mth	4 mth	9-12 mth
Nb of years since first S1 *	10	4	17
Nb of patients *	130	250	300
	200		
	650-750		
* Estimation based on 2013 data			

Most published and acknowledged

Background

Attachment

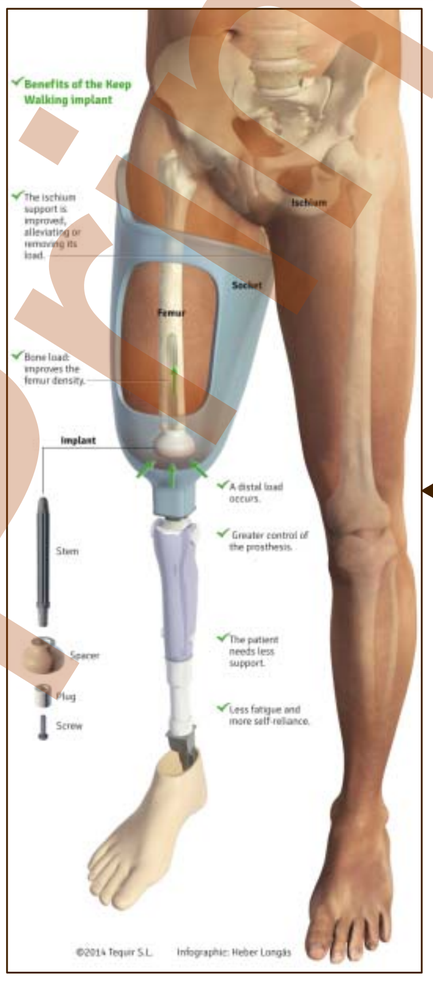
Socket

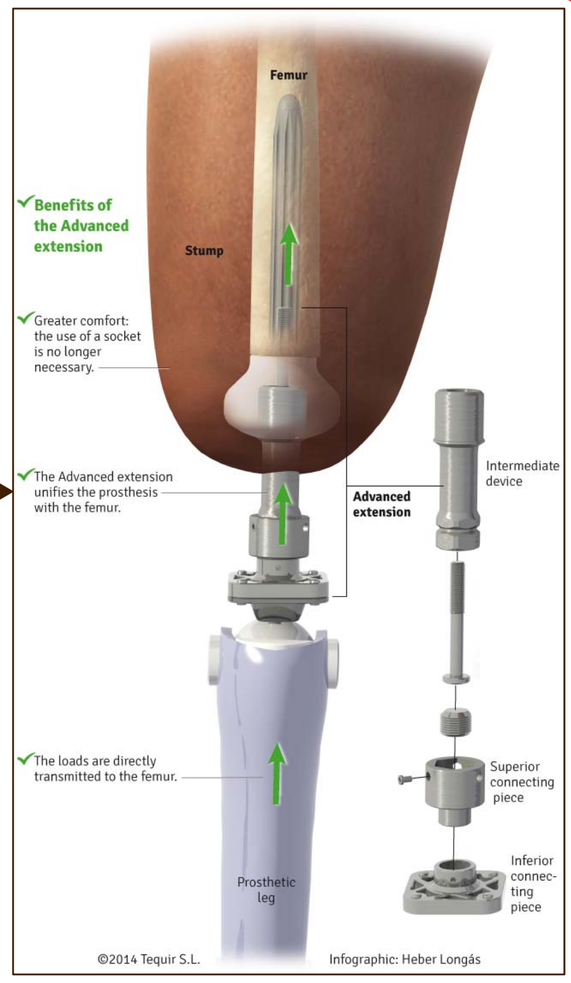
“Hybrid”

BAP

Screw-typ

Press-fit





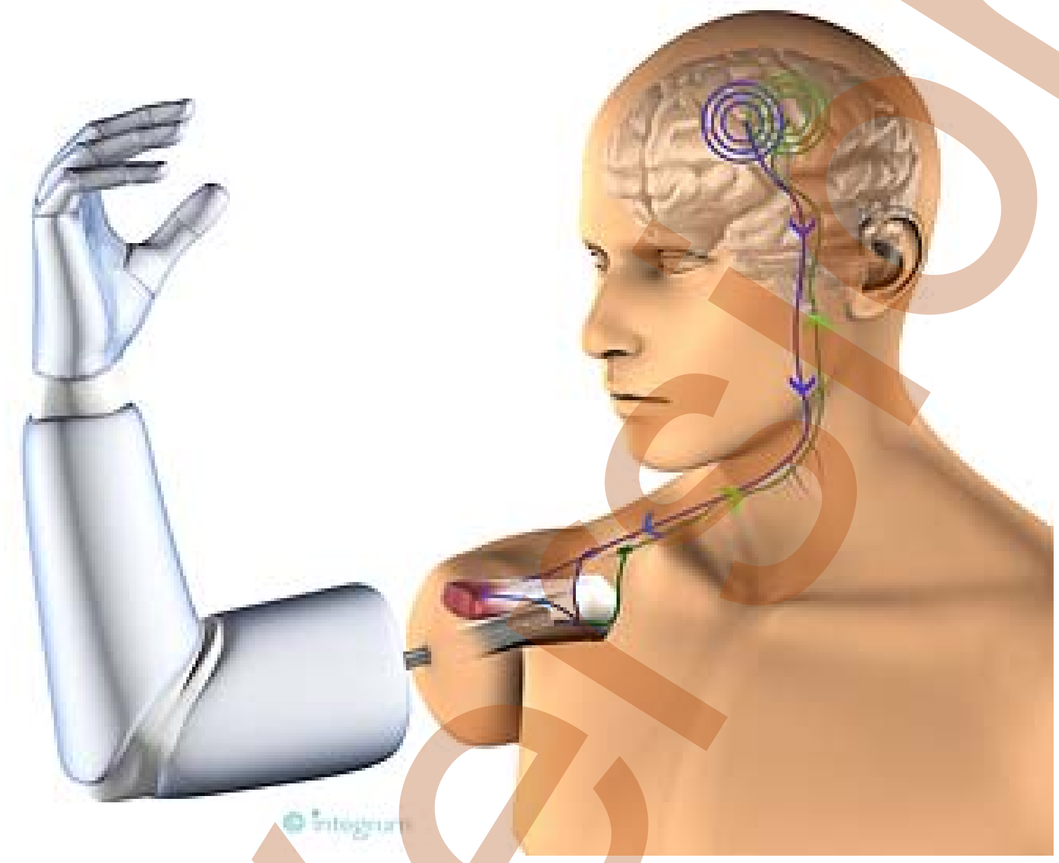
http://implantekeepwalking.es

Background

Attachment

- Socket
- “Hybrid”
- BAP
- Screw-typ
- Press-fit

BANP



http://www.chalmers.se/en/news/Pages/Thought-controlled-prosthesis-is-changing-the-lives-of-amputees.aspx

Bone-anchored prostheses from rehabilitation and beyond: is what you see is what you get?

Rehabilitation

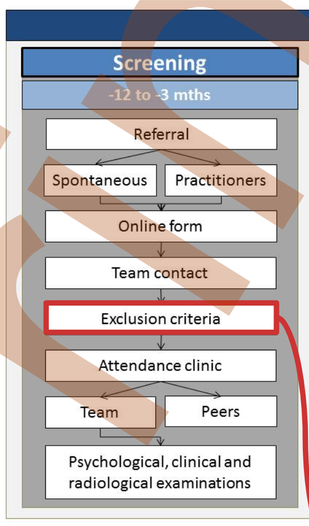
Pathways

Clinical pathways

Rehabilitation

Pathways

Clinical pathways



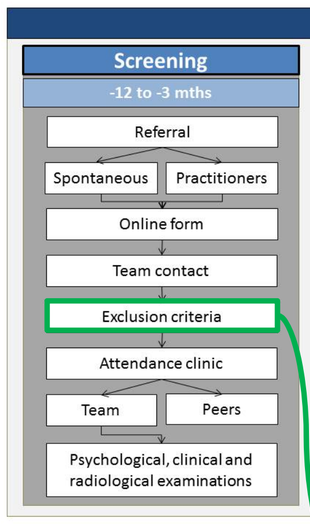
Exclusion criteria

- **Diabetes**
- **Smoking**
- **Severe vascular disease**
- **Peripheral vascular disease**
- **Growing skeleton**
- **Severe learning disability**
- **Lack of compliance**
- **Chemotherapy treatment**
- **Inability to adhere program / pregnancy**
- **Arteriosclerosis**
- **Mental illness**

Hagberg, K. and R. Branemark, One hundred patients treated with osseointegrated transfemoral amputation prostheses--rehabilitation perspective. J Rehabil Res Dev, 2009. 46(3): p. 331-44.

Rehabilitation

Pathways



Inclusion criteria

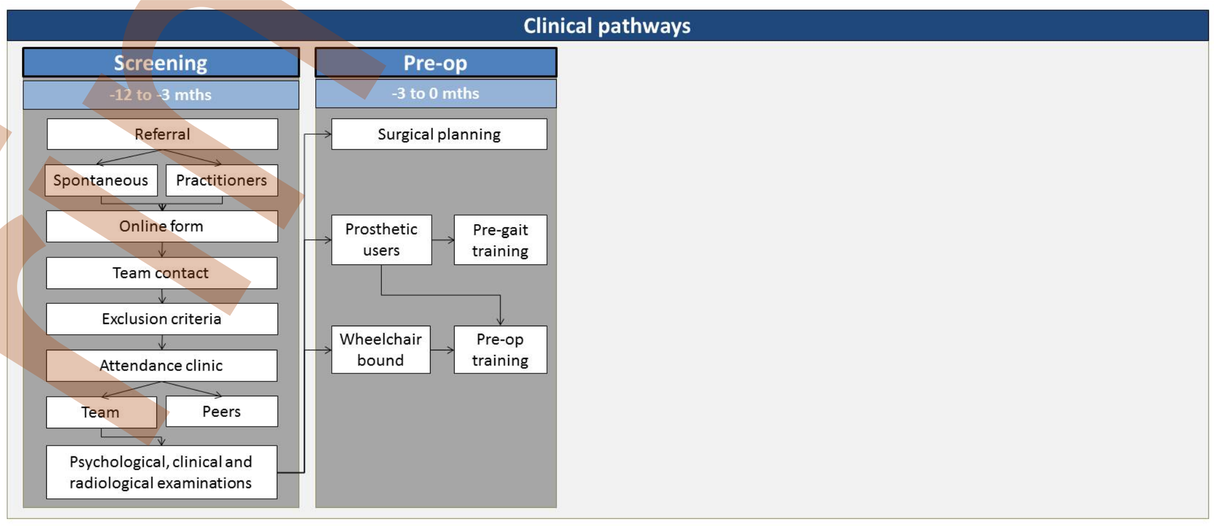
- **Socket-related problems**
- **Inability to use a conventional prosthesis**
- **Use of prosthesis limited significantly**
- Short residual limb
- Dimension of residual bone
- Quality of residual bone
- Bilateral amputation
- Understanding the risks of complications
- Willing to comply with treatment protocol
- Following the rehabilitation protocol
- Acceptance of disability

K0 to K2

Hagberg, K. and R. Branemark, One hundred patients treated with osseointegrated transfemoral amputation prostheses--rehabilitation perspective. J Rehabil Res Dev, 2009. 46(3): p. 331-44.

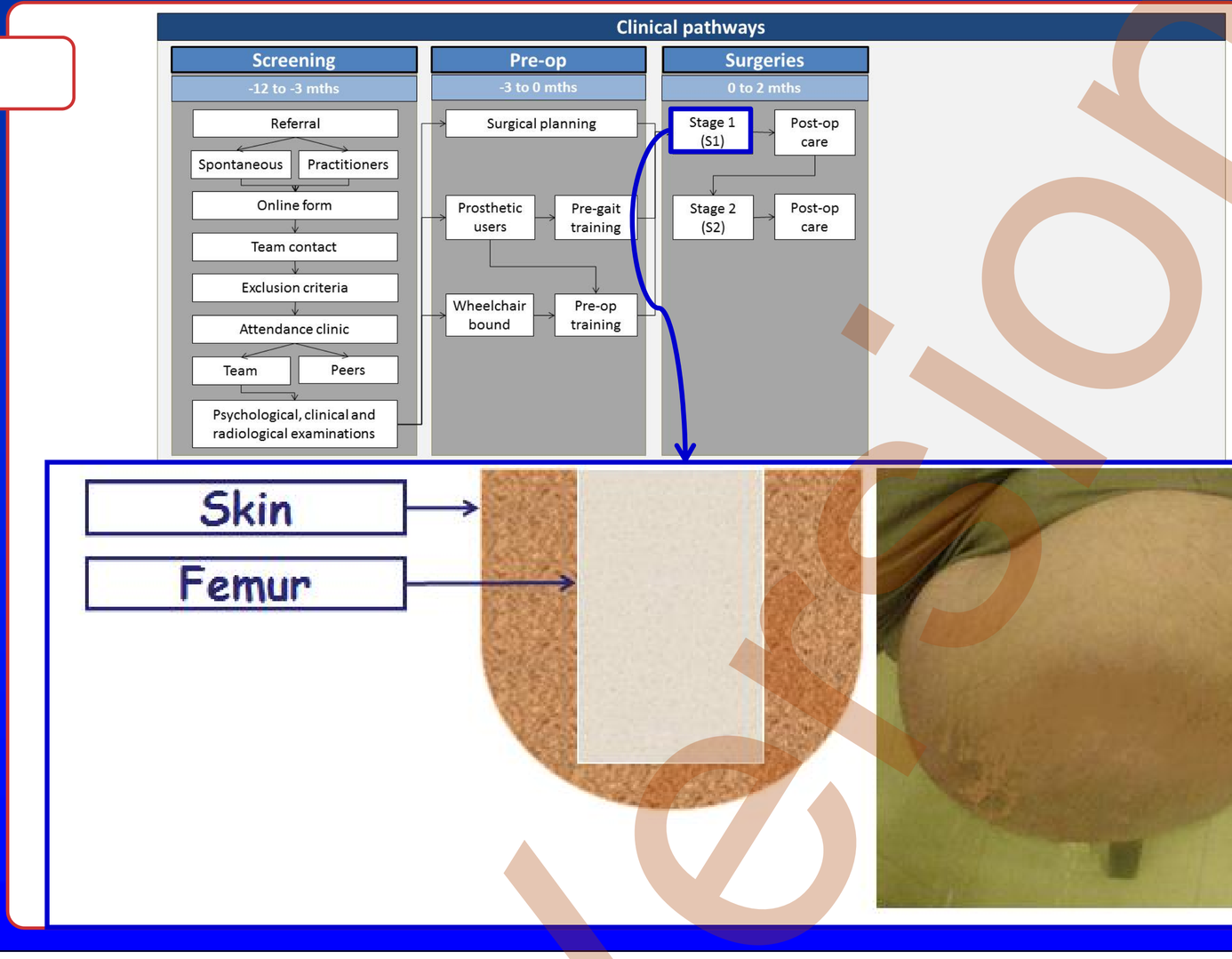
Rehabilitation

Pathways



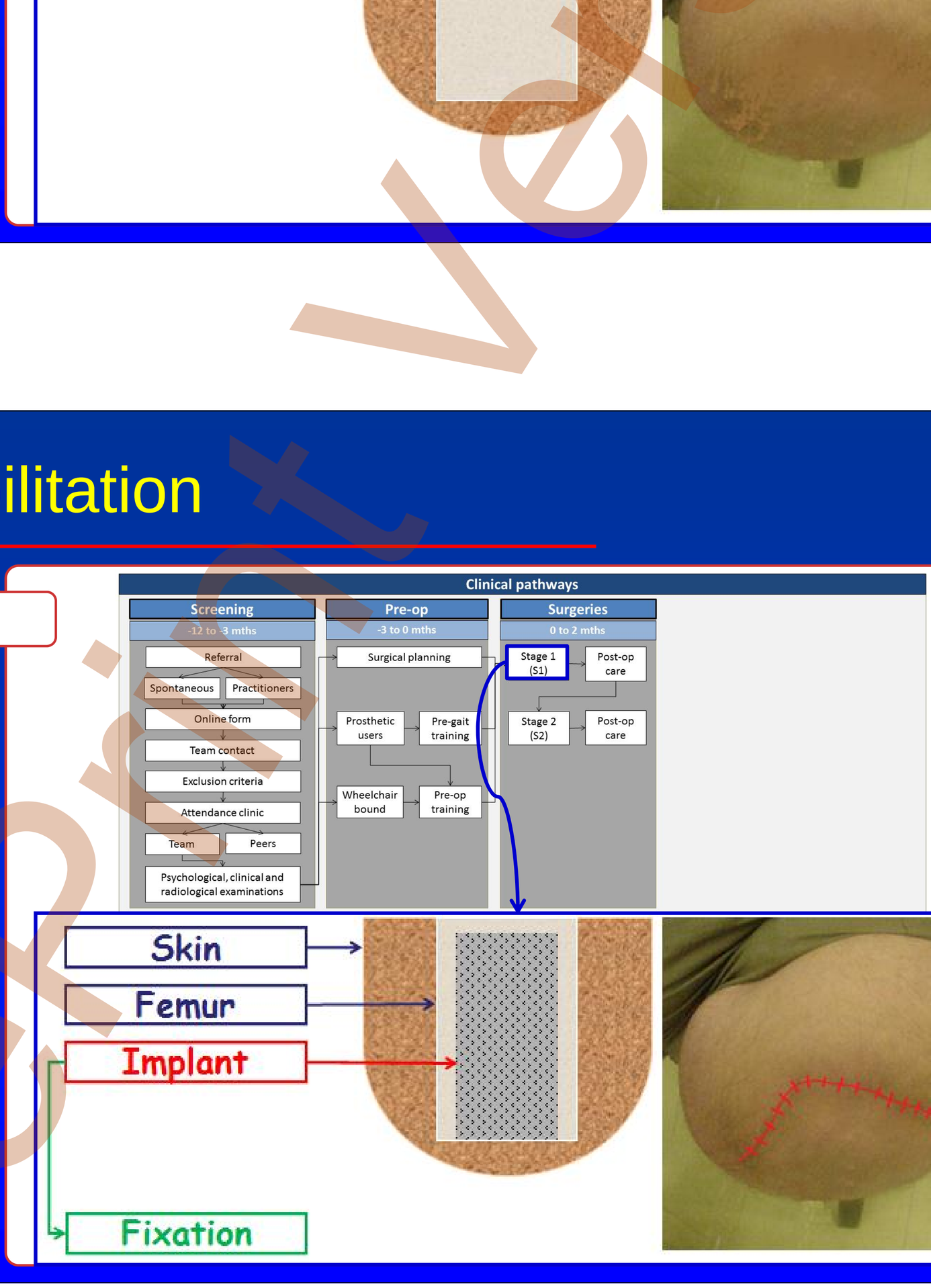
Rehabilitation

Pathways



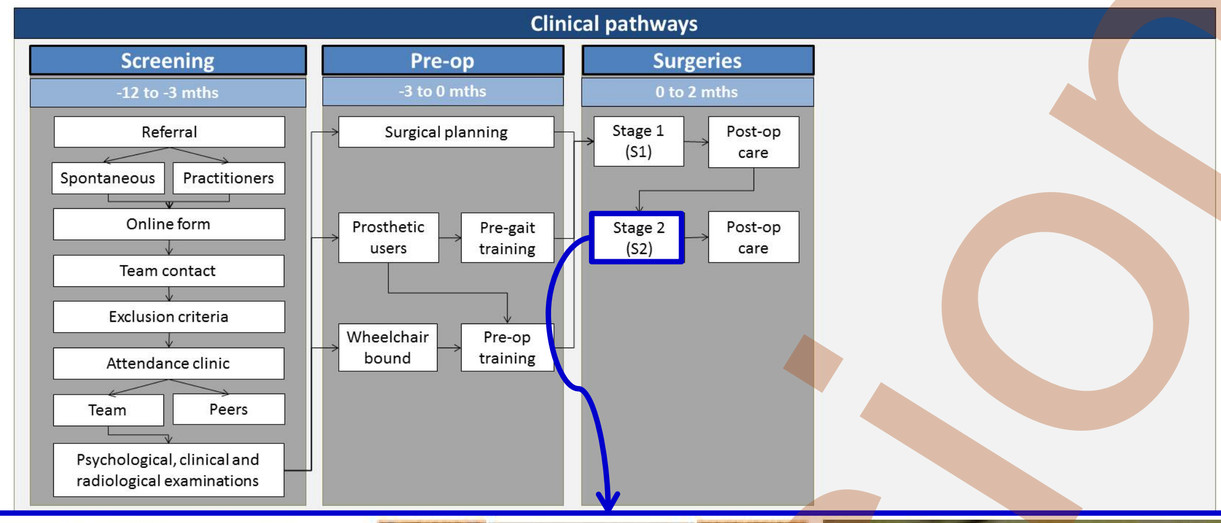
Rehabilitation

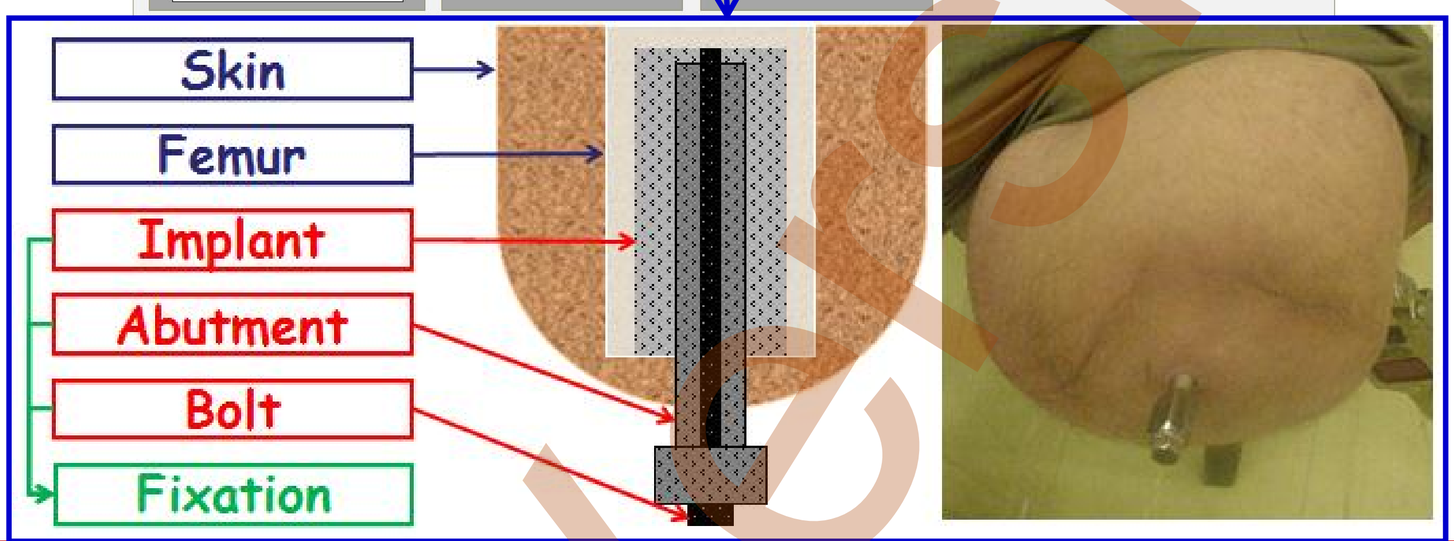
Pathways



Rehabilitation

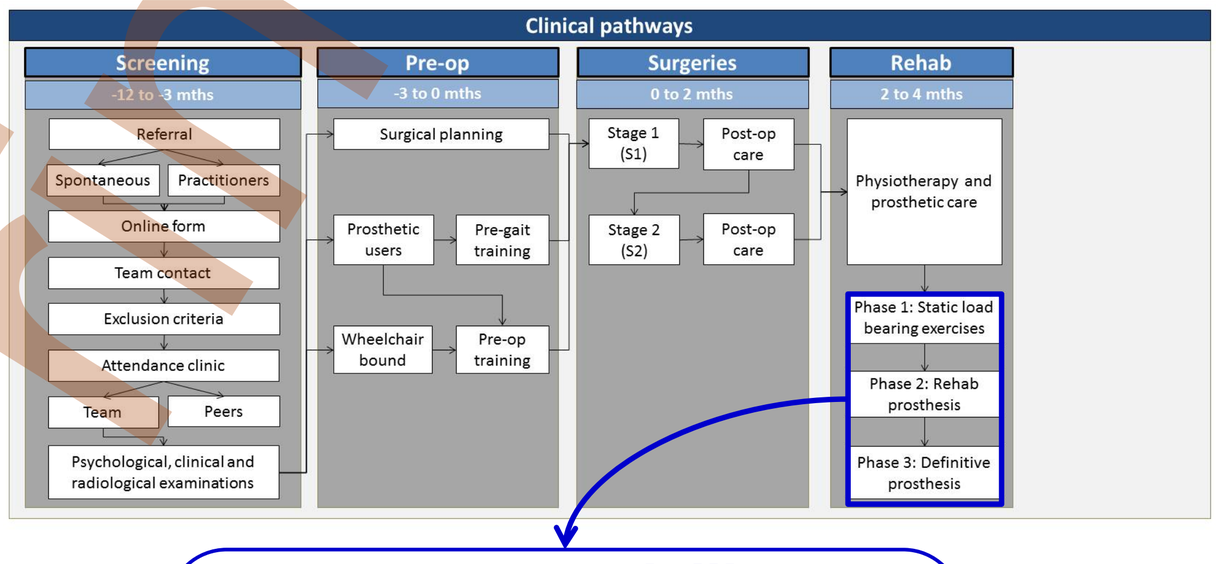
Pathways





Rehabilitation

Pathways

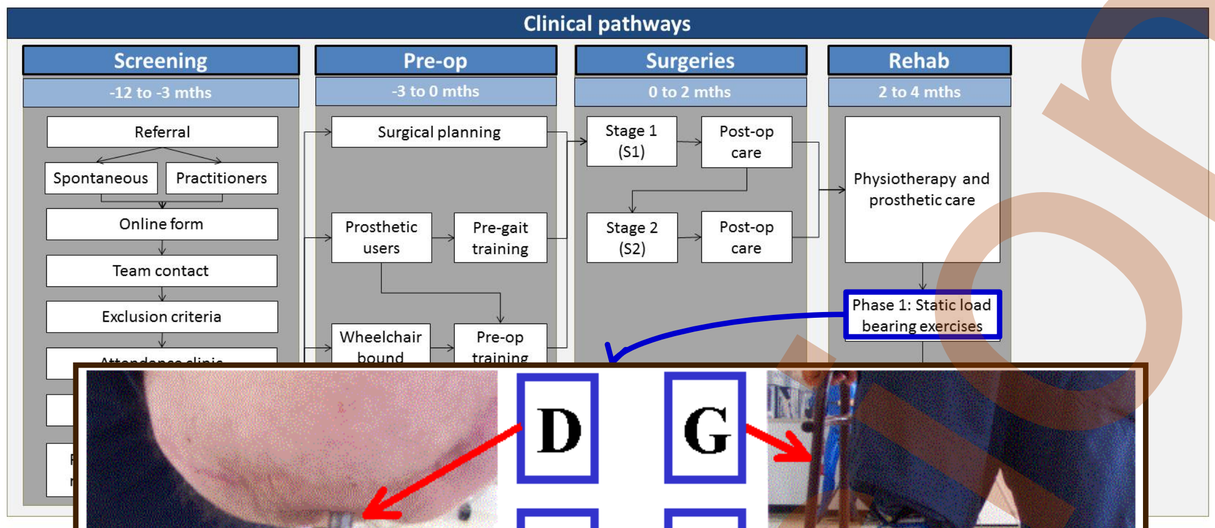


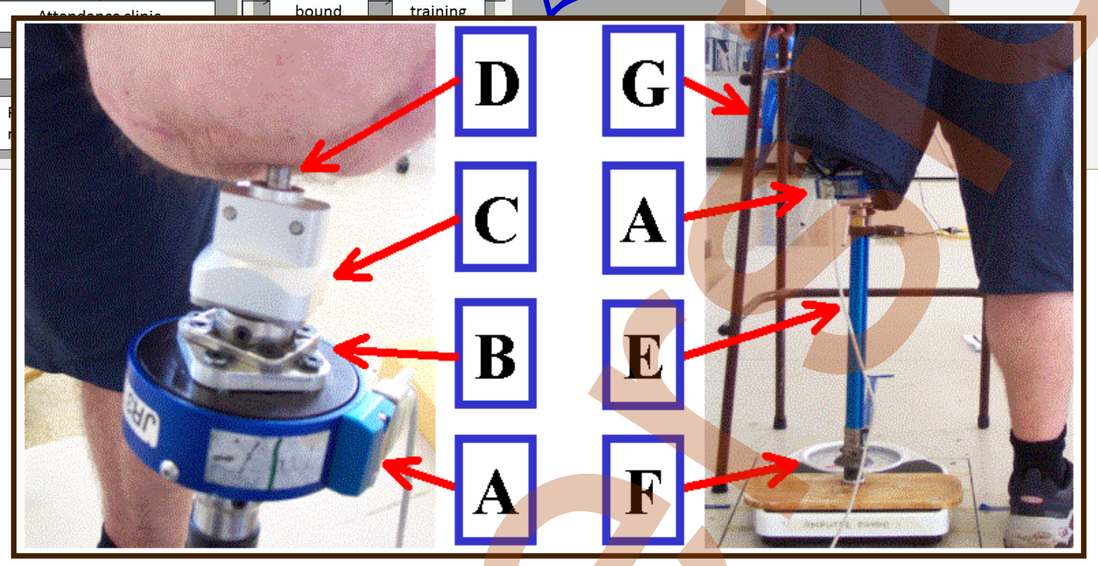
Bone remodelling
=
Right load
+
Right time

Vertriest S, Coorevits P, Brånemark R, Hagberg K, Brånemark R, Vanderstraeten G, Frossard L. Static load bearing exercises of individuals with transfemoral amputation fitted with an osseointegrated implant: Reliability of kinetic data. IEEE Transactions on Neural Systems and Rehabilitation Engineering. 2015.

Rehabilitation

Pathways

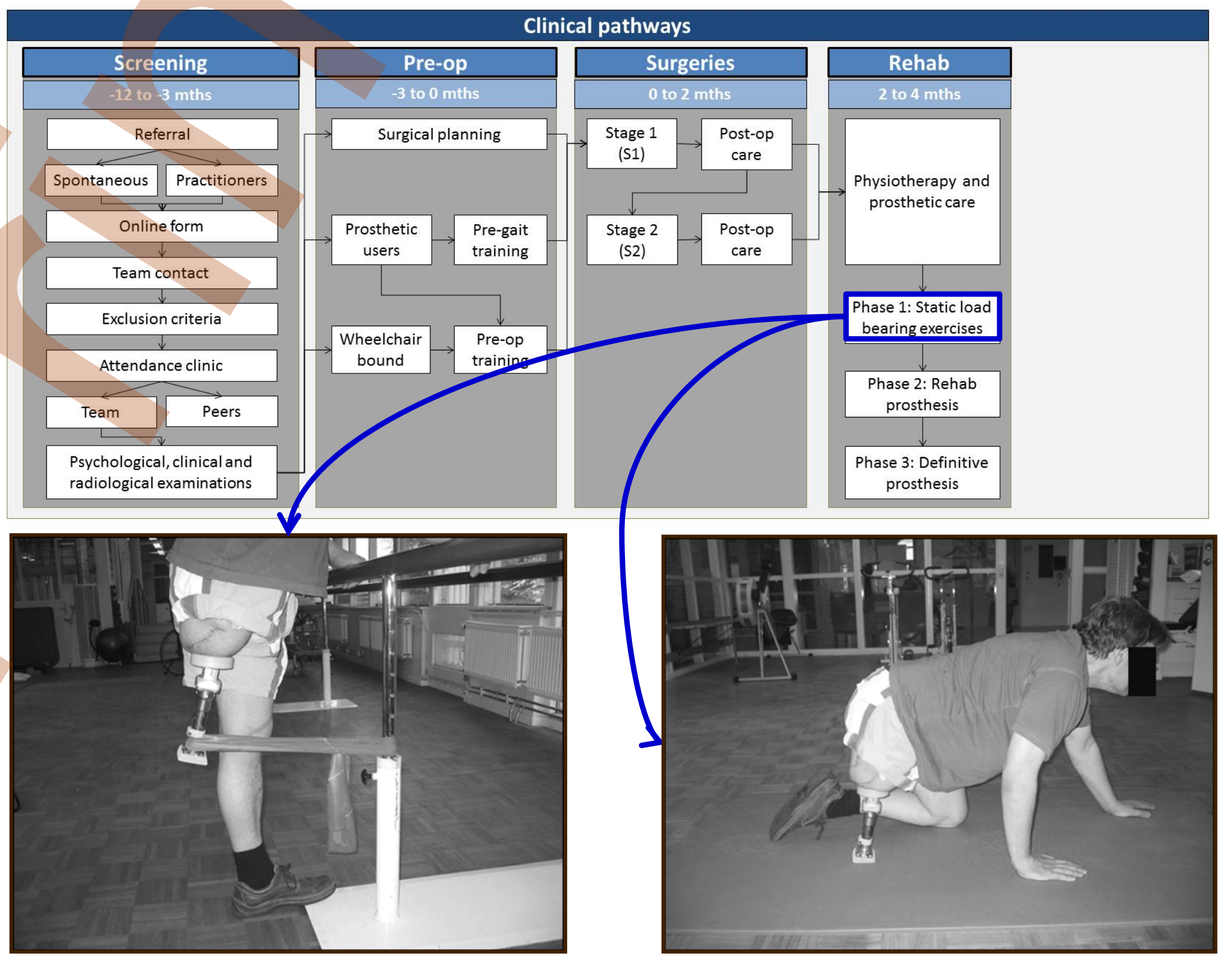




Frossard, L., D.L. Gow, K. Hagberg, N. Cairns, B. Contoyannis, S. Gray, R. Brånemark, and M. Pearcy, Apparatus for monitoring load bearing rehabilitation exercises of a transfemoral amputee fitted with an osseointegrated fixation: A proof-of-concept study. Gait and Posture, 2010. 31(2): p. 223-228

Rehabilitation

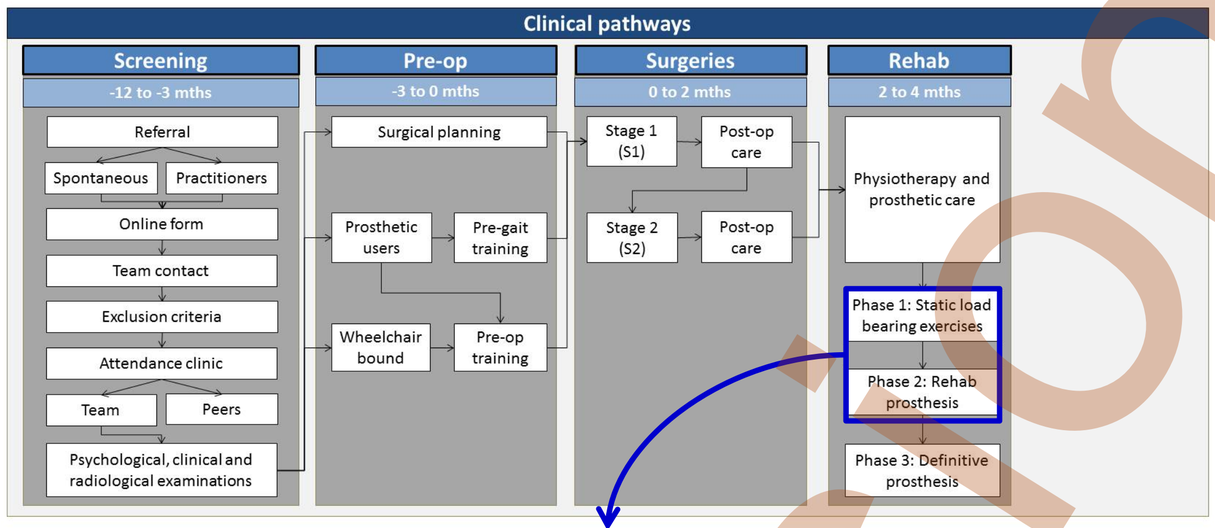
Pathways

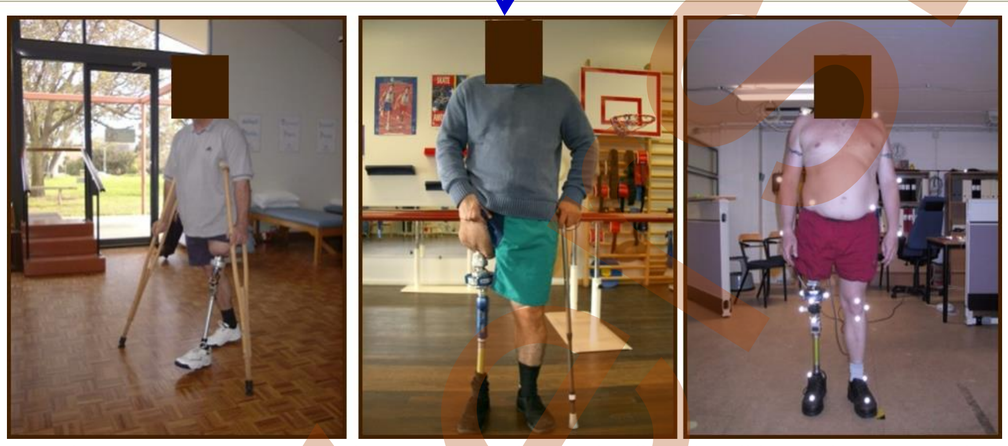


Hagberg, K. and R. Brånemark, One hundred patients treated with osseointegrated transfemoral amputation prostheses - the rehabilitation perspective. Journal of Rehabilitation Research & Development, 2009. 43(3): p. 331-344

Rehabilitation

Pathways

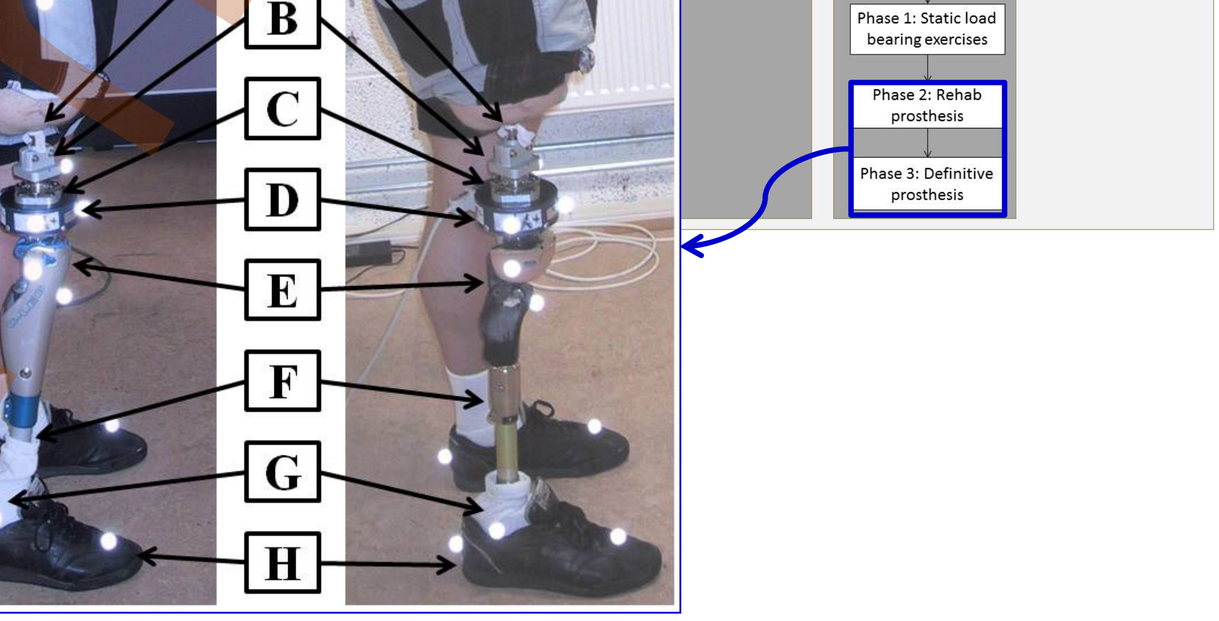




Frossard, L., K. Hagberg, E. Haggstrom, and R. Branemark, Load-relief of walking aids on osseointegrated fixation: instrument for evidence-based practice. NSRE, IEEE Transactions on, 2009. 17(1): p. 9-14

Rehabilitation

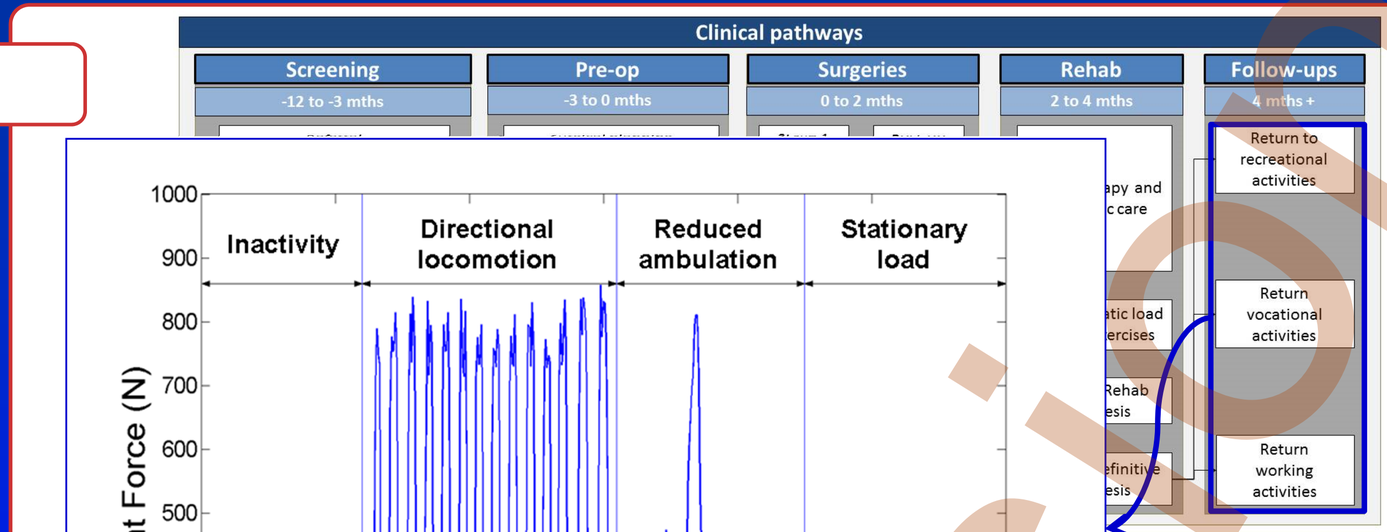
Pathways



Frossard, L., E. Haggstrom, K. Hagberg, and P. Branemark, Load applied on a bone-anchored transfemoral prosthesis: characterisation of prosthetic components – A case study Journal of Rehabilitation Research & Development, 2013. 50(5): p. 619–634.

Rehabilitation

Pathways



Frossard L, Stevenson N, Sullivan J, Uden M, Pearcy M. Categorisation of activities of daily living of lower limb amputees during short-term use of a portable kinetic recording system: a preliminary study. Journal of Prosthetics and Orthotics. 2011. 23 (1). p 2-11.

Bone-anchored prostheses from rehabilitation and beyond: is what you see is what you get?

Benefits

Benefits

HRQoL

SF-36

Health-related quality of life: SF-36

Table III. Questionnaire for Persons with a Transfemoral Amputation (Q-TFA) and Short-Form (SF)-36 scores at baseline and change from baseline to 12- and to 24-month follow-up, respectively. Three patients failed to complete the whole questionnaire at each visit

	Mean score (range) [median; SD] (no. patients)		
Variable	**Baseline**	**Change from baseline to 12 mths**	**Change from baseline to 24 mths**
SF-36			
Physical function	35 (0 to 85) [30; 22] (n = 51)	22 (-40 to 70) [20; 24] (n = 47)§	23 (-23 to 75) [25; 21] (n = 45)§
Role-physical	41 (0 to 100) [25; 42] (n = 50)	24 (-50 to 100) [25; 44] (n = 45)§	22 (-50 to 100) [13; 36] (n = 44)§
Bodily pain	55 (10 to 100) [51; 26] (n = 51)	7 (-52 to 74) [0; 26] (n = 47)	6 (-61 to 59) [9; 30] (n = 45)
General health	78 (37 to 100) [82; 18] (n = 51)	3 (-32 to 40) [0; 17] (n = 47)	-1 (-42 to 40) [0; 18] (n = 45)
Vitality	60 (15 to 90) [60; 20] (n = 51)	5 (-50 to 45) [5; 19] (n = 47)	3 (-70 to 45) [5; 23] (n = 45)
Social function	78 (13 to 100) [88; 25] (n = 51)	2 (-50 to 50) [0; 24] (n = 47)	1 (-100 to 63) [0; 30] (n = 45)
Role-emotional	75 (0 to 100) [100; 39] (n = 50)	5 (0 to 100) [0; 43] (n = 46)	0 (0 to 100) [0; 45] (n = 44)
Mental health	74 (4 to 100) [80; 21] (n = 51)	2 (-44 to 40) [0; 18] (n = 47)	2 (-76 to 40) [4; 24] (n = 45)
SF-36 Physical Component Summary‡	32 (18 to 55) [31;8] (n = 50)	8 (-11 to 29) [8;10] (n = 45)	8 (-8 to 29) [9;9] (n = 44)
SF-36 Mental Component Summary‡	53 (19 to 69) [57; 13] (n = 50)	-2 (-33 to 23) [-2; 11] (n = 45)	-3 (-44 to 22) [0; 15] (n = 44)

* a Prosthetic Use Score of 0 means the patient is not using a prosthesis and consequently the Prosthetic Mobility Score, Problem Score and Global Score could not be answered, hence results for lower numbers of patients in those scores[1]
† the Problem Score is reversed, which means a lower figure indicates fewer problems related to amputation and prosthesis
‡ SF-36 Physical and Mental Component Summaries are normalised to the general population (mean 50 (SD 10))[13]
§ $p < 0.001$

Branemark, R., O. Berlin, K. Hagberg, P. Bergh, B. Gunterberg, and B. Rydevik, A novel osseointegrated percutaneous prosthetic system for the treatment of patients with transfemoral amputation: A prospective study of 51 patients. Bone Joint J, 2014. 96(1): p. 106-113. Errata : Haddad, Bone Joint J: 2014, 96-B 106-113

Benefits

HRQoL

SF-36

Health-related quality of life: SF-36

Table III. Questionnaire for Persons with a Transfemoral Amputation (Q-TFA) and Short-Form (SF)-36 scores at baseline and change from baseline to 12- and to 24-month follow-up, respectively. Three patients failed to complete the whole questionnaire at each visit

	Mean score (range) [median; SD] (no. patients)		
Variable	**Baseline**	**Change from baseline to 12 mths**	**Change from baseline to 24 mths**
SF-36			
Physical function			
Role-physical			
Bodily pain			
General health			
Vitality			
Social function			
Role-emotional			
Mental health			
SF-36 Physical Component Summary‡			
SF-36 Mental Component Summary‡			

* a Prosthetic Use Score of 0 means the patient is not using a prosthesis and consequently the Prosthetic Mobility Score, Problem Score and Global Score could not be answered, hence results for lower numbers of patients in those scores[1]
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Benefits

HRQoL

SF-36

Q-TFA

Health-related quality of life: Q-TFA

Table III. Questionnaire for Persons with a Transfemoral Amputation (Q-TFA) and Short-Form (SF)-36 scores at baseline and change from baseline to 12- and to 24-month follow-up, respectively. Three patients failed to complete the whole questionnaire at each visit

	Mean score (range) [median; SD] (no. patients)		
Variable	**Baseline**	**Change from baseline to 12 mths**	**Change from baseline to 24 mths**
Q-TFA*			
Prosthetic use score	47 (0 to 100) [52; 37] (n = 51)	34 (-23 to 100) [29; 29] (n = 44)§	32 (-100 to 100) [29; 41] (n = 45)§
Prosthetic mobility score	52 (0 to 82) [56; 20] (n = 42)	14 (-29 to 46) [15; 17] (n = 36)§	18 (-29 to 48) [17; 16] (n = 37)§
Problem score†	44 (5 to 77) [48; 19] (n = 42)	-28 (-57 to 2) [-33; 16] (n = 36)§	-27 (-59 to 7) [-30; 16] (n = 37)§
Global score	38 (0 to 92) [33; 19] (n = 42)	37 (-17 to 84) [34; 26] (n = 36)§	39 (0 to 92) [34; 24] (n = 37)§
Overall situation (n, %)			
Extremely poor	5 (*10*)	n = 42	n = 45
Poor	15 (*29*)	Declined: 2 (*5*)	Declined: 3 (*7*)
Average	17 (*33*)	No change: 11 (*26*)	No change: 11 (*24*)
Good	9 (*18*)	Improved: 29 (*69*)§	Improved: 31 (*69*)§
Extremely good	5 (*10*)		

Branemark, R., O. Berlin, K. Hagberg, P. Bergh, B. Gunterberg, and B. Rydevik, A novel osseointegrated percutaneous prosthetic system for the treatment of patients with transfemoral amputation: A prospective study of 51 patients. Bone Joint J, 2014. 96(1): p. 106-113.

Benefits

- HRQoL
- SF-36
- Q-TFA

Health-related quality of life: Q-TFA

Table III. Questionnaire for Persons with a Transfemoral Amputation (Q-TFA) and Short-Form (SF)-36 scores at baseline and change from baseline to 12- and to 24-month follow-up, respectively. Three patients failed to complete the whole questionnaire at each visit

	Mean score (range) [median; SD] (no. patients)		
Variable	**Baseline**	**Change from baseline to 12 mths**	**Change from baseline to 24 mths**
Q-TFA*			
Prosthetic use score			
Prosthetic mobility score			
Problem score†			
Global score			
Overall situation (n, %)			
Extremely poor			
Poor			
Average			
Good			
Extremely good			

- Q-TFA

Branemark, R., O. Berlin, K. Hagberg, P. Bergh, B. Gunterberg, and B. Rydevik, A novel osseointegrated percutaneous prosthetic system for the treatment of patients with transfemoral amputation: A prospective study of 51 patients. Bone Joint J, 2014. 96(1): p. 106-113.

Benefits

- HRQoL
- SF-36
- Q-TFA
- Sitting

Sitting

http://osseointeg.ning.com/profile/ErikAx

http://www.sahlgrenska.se/su/osseointegration

Benefits

- HRQoL
- SF-36
- Q-TFA
- Sitting
- **Image**

Body representation

N=13

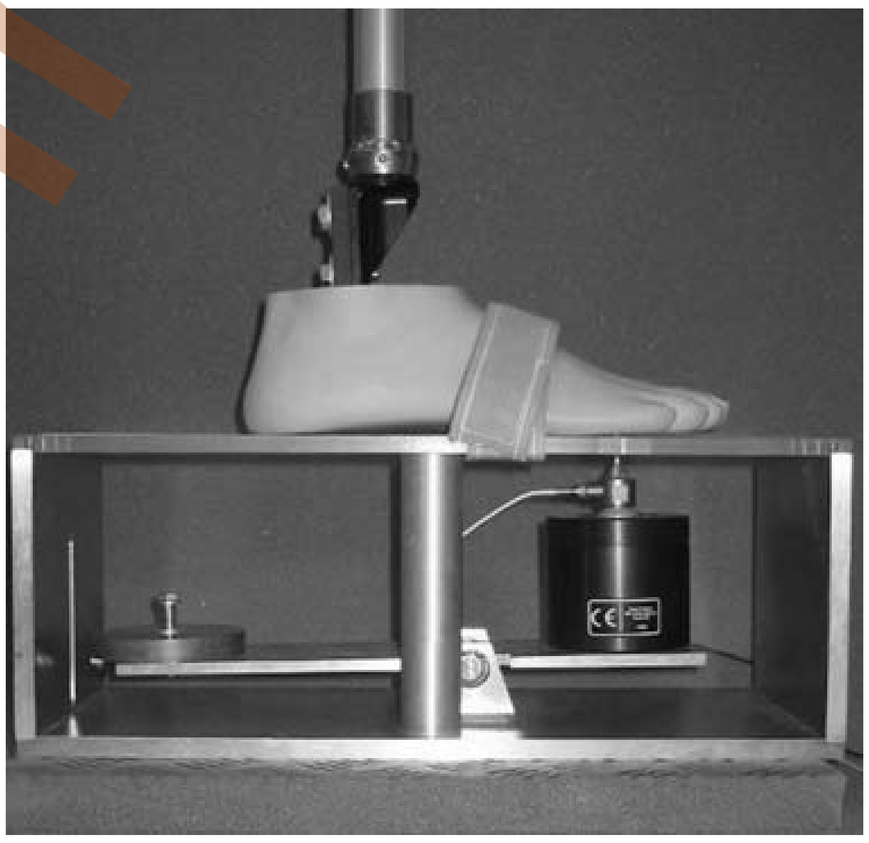
“ The prosthesis* (OI-prosthesis) *is a part of me since it works so well, and you don’t have to think that it’s a problem and that it should be hard and so forth . . . it’s more like a substitute, my ¨ pretend leg ¨ ”

http://news.bme.com/tag/amputation/

Lundberg, M., K. Hagberg, and J. Bullington, My prosthesis as a part of me: a qualitative analysis of living with an osseointegrated prosthetic limb. Prosthetics and Orthotics International, 2011. 35(2): p. 207-214

Benefits

- HRQoL
- SF-36
- Q-TFA
- Sitting
- Image
- **OIperception**



Hagberg, K., E. Häggström, S. Jönsson, B. Rydevik, and R. Brånemark, Osseoperception and Osseointegrated Prosthetic Limbs, P. Gallagher, D. Desmond, and M. MacLachlan, Editors. 2008, Springer London. p. 131-140

Benefits

- HRQoL
- SF-36
- Q-TFA
- Sitting
- Image
- OIperceptio
- **Attachment**

Doning and doffing

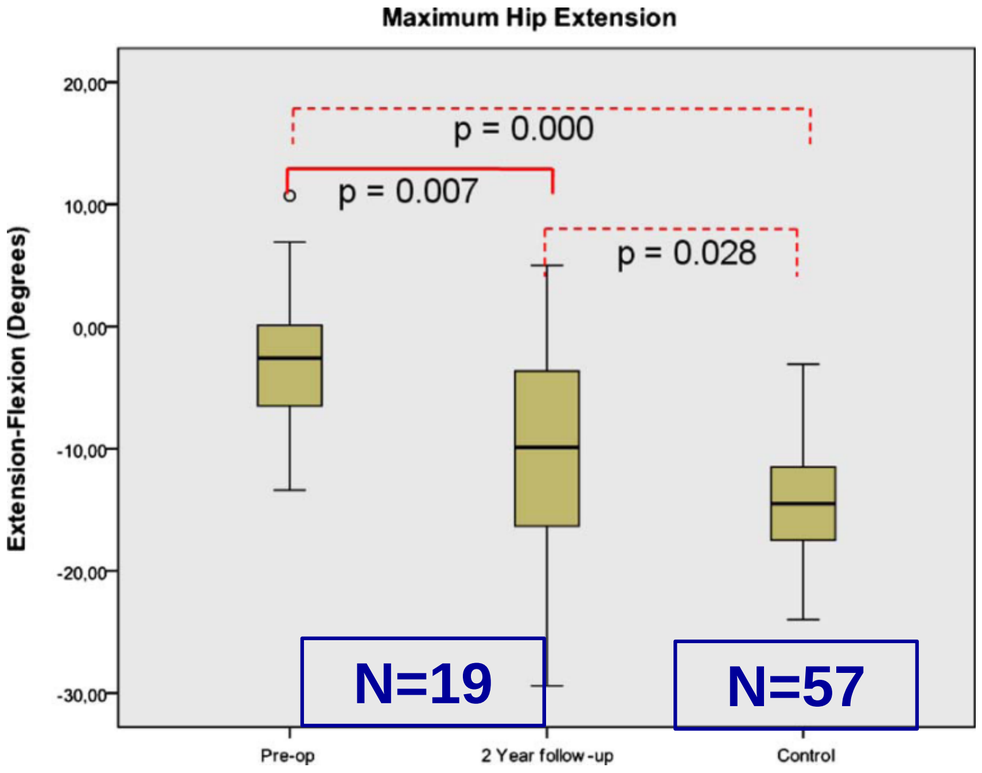
Hagberg, K., E. Häggström, S. Jönsson, B. Rydevik, and R. Brånemark, Osseoperception and Osseointegrated Prosthetic Limbs, P. Gallagher, D. Desmond, and M. MacLachlan, Editors. 2008, Springer London. p. 131-140

Benefits

- HRQoL
- SF-36
- Q-TFA
- Sitting
- Image
- OIperceptio
- Attachment
- **Hip ROM**

Hip range of movement

http://osseointeg.ning.com/profile/ErikAx



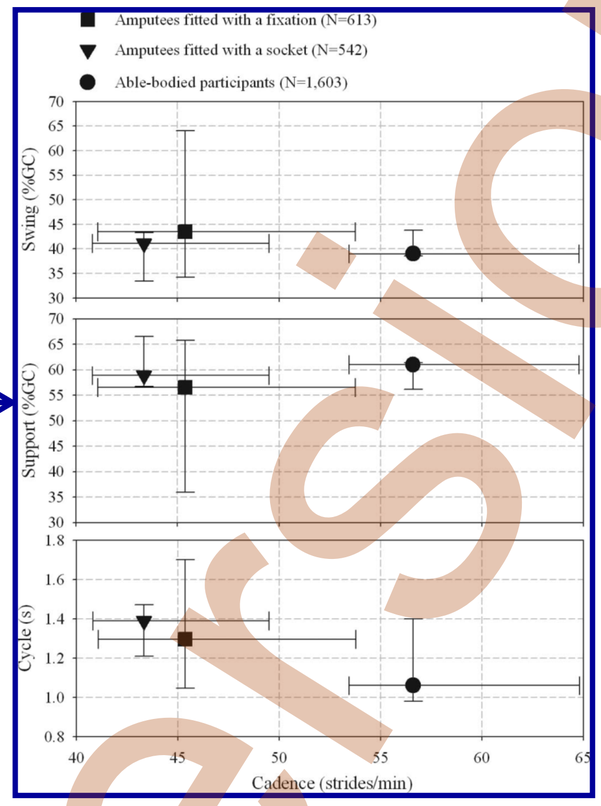
Tranberg, R., R. Zügner, and J. Kärrholm, Improvements in hip- and pelvic motion for patients with osseointegrated trans-femoral prostheses. Gait & Posture, 2011. 33(2): p. 165-168

Benefits

- HRQoL
- SF-36
- Q-TFA
- Sitting
- Image
- OIperceptio
- Attachment
- Hip ROM
- **Gait**

Walking abilities

N=12



Frossard, L., K. Hagberg, E. Haggstrom, D. Lee Gow, R. Branemark, and M. Pearcy, Functional outcome of transfemoral amputees fitted with an osseointegrated fixation: Temporal gait characteristics. Journal of Prosthetics and Orthotics, 2010. 22(1): p. 11-20

Benefits

- HRQoL
- SF-36
- Q-TFA
- Sitting
- Image
- OIperceptio
- Attachment
- Hip ROM
- **Gait**

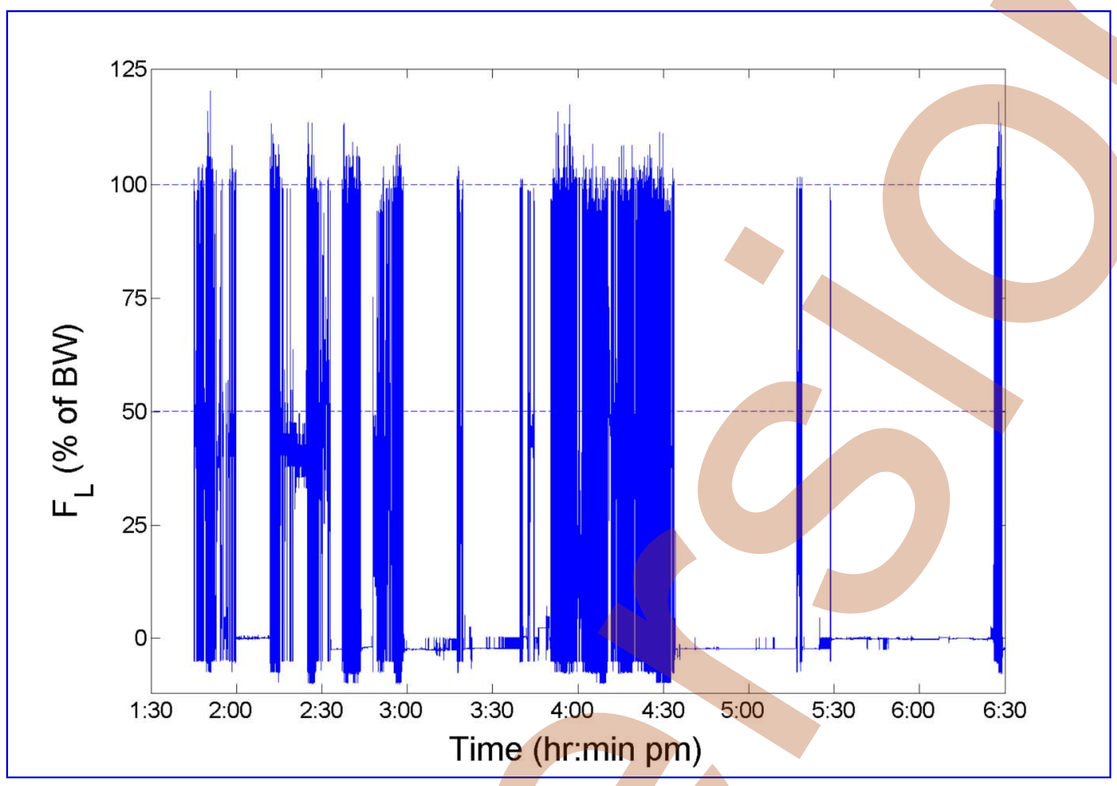
Number of steps

Source: Facebook accessed 21/11/2015

Benefits

- HRQoL
- SF-36
- Q-TFA
- Sitting
- Image
- OIperceptio
- Attachment
- Hip ROM
- **Gait**

Activities of daily living



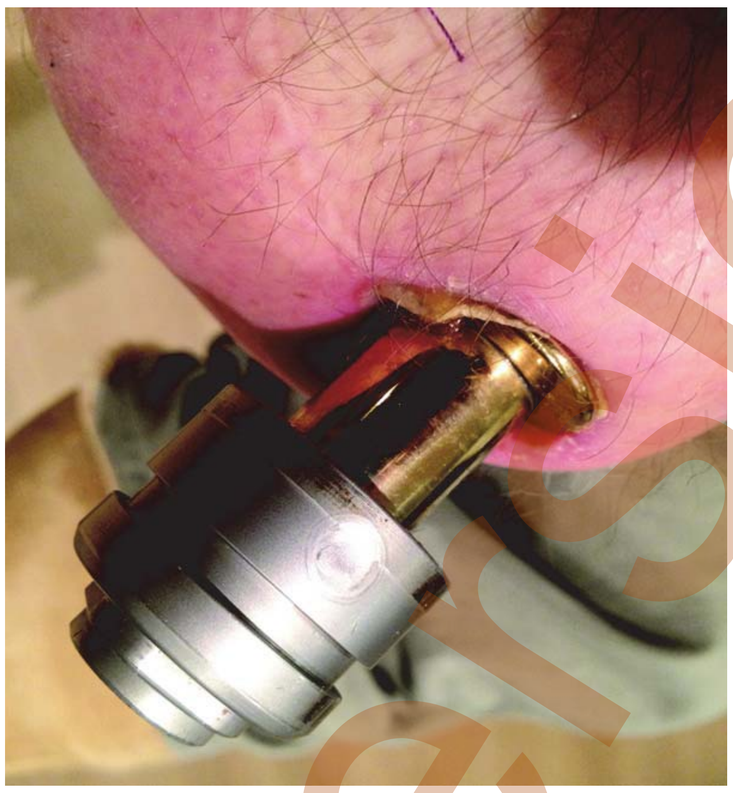
Frossard L, Stevenson N, Smeathers J, Häggström E, Hagberg K, Sullivan J, Ewins D, Lee Gow D, Gray S, Brånemark R. Monitoring of the load regime applied on the osseointegrated fixation of a trans-femoral amputee: A tool for evidence-based practice. Prosthetics and Orthotics International. 2008. 32 (1).

Safety

Safety

Infections

Overview – Superficial infections



[1] Al Muderis, M., K. Tetsworth, A. Khemka, S. Wilmot, B. Bosley, S.J. Lord, and V. Glatt, The Osseointegration Group of Australia Accelerated Protocol (OGAAP-1) for two-stage osseointegrated reconstruction of amputated limbs. Bone & Joint Journal, 2016. 98-B(7): p. 952-960.

Safety

Infections

Overview – Superficial infections

	Inclusion	Follow-up
		?
Reference		[1]
Number of participants in study		86
Low-grade soft-tissue infection = Cellulitis with signs of inflammation (redness, swelling, warmth, stinging pain, pain that increases on loading, tense)		28%

[1] Al Muderis, M., A. Khemka, S. Lord, H. Van de Meent, and J. Frolke, Safety of Osseointegrated Implants for Transfemoral Amputees: A Two-Center Prospective Cohort Study. The Journal of Bone & Joint Surgery, 2016. 98(11): p. 900-909.

Safety

Infections

Overview – Superficial infections

	Inclusion		Follow-up	
			(2-3 yrs)	(S2-2 yrs)
Reference	[1]	[2]	[1]	[2]
Number of participants in study	39	51	39	51
Local soft tissue infection in the skin penetration area / Superficial infection	17%	11%	29%	80%

[1] Tillander, J., K. Hagberg, L. Hagberg, and R. Branemark, Osseointegrated Titanium Implants for Limb Prostheses Attachments: Infectious Complications. Clinical Orthopaedic Related Research, 2010. 468(10): p. 2781-2788

[2] Branemark, R., O. Berlin, K. Hagberg, P. Bergh, B. Gunterberg, and B. Rydevik, A novel osseointegrated percutaneous prosthetic system for the treatment of patients with transfemoral amputation: A prospective study of 51 patients. Bone Joint J, 2014. 96(1): p. 106-113.

Safety

Infections

Overview – Superficial infections

	Inclusion		Follow-up	
			(2-3 yrs)	(S2-2 yrs)
Reference	[1]	[2]	[1]	[2]
Number of participants in study	39	51	39	51
Local soft tissue infection in the skin penetration area / Superficial infection	17%	11%		

100%

Cleaning

[1] Tillander, J., K. Hagberg, L. Hagberg, and R. Branemark, Osseointegrated Titanium Implants for Limb Prostheses Attachments: Infectious Complications. Clinical Orthopaedic Related Research, 2010. 468(10): p. 2781-2788

[2] Branemark, R., O. Berlin, K. Hagberg, P. Bergh, B. Gunterberg, and B. Rydevik, A novel osseointegrated percutaneous prosthetic system for the treatment of patients with transfemoral amputation: A prospective study of 51 patients. Bone Joint J, 2014. 96(1): p. 106-113.

Safety

Infections

Overview - Deep infections

[1] Al Muderis, M., K. Tetsworth, A. Khemka, S. Wilmot, B. Bosley, S.J. Lord, and V. Glatt, The Osseointegration Group of Australia Accelerated Protocol (OGAAP-1) for two-stage osseointegrated reconstruction of amputated limbs. Bone & Joint Journal, 2016. 98-B(7): p. 952-960.

Safety

Infections

Overview – Superficial infections

	Inclusion	Follow-up
		?
Reference		[1]
Number of participants in study		86
High-grade soft-tissue infection = Pus collection, purulent discharge, raised level of C-reactive protein		5%

[1] Al Muderis, M., A. Khemka, S. Lord, H. Van de Meent, and J. Frolke, Safety of Osseointegrated Implants for Transfemoral Amputees: A Two-Center Prospective Cohort Study. The Journal of Bone & Joint Surgery, 2016. 98(11): p. 900-909.

Safety

Infections

Overview - Deep infections

	Inclusion		Follow-up	
			(2-3 yrs)	(S2-2 yrs)
Reference	[1]	[2]	[1]	[2]
Number of participants in study	39	51	39	51
Definite implant infection / Deep implant infection	5%	11%	15%	6%

[1] Tillander, J., K. Hagberg, L. Hagberg, and R. Branemark, Osseointegrated Titanium Implants for Limb Prostheses Attachments: Infectious Complications. Clinical Orthopaedic Related Research, 2010. 468(10): p. 2781-2788

[2] Branemark, R., O. Berlin, K. Hagberg, P. Bergh, B. Gunterberg, and B. Rydevik, A novel osseointegrated percutaneous prosthetic system for the treatment of patients with transfemoral amputation: A prospective study of 51 patients. Bone Joint J, 2014. 96(1): p. 106-113.

Safety

Infections

Overview - Deep infections

	Inclusion		Follow-up	
			(2-3 yrs)	(S2-2 yrs)
Reference	[1]	[2]	[1]	[2]
Number of participants in study	39	51	39	51
Definite implant infection / Deep implant infection	5%			6%

≤20%

Short course of antibiotics

[1] Tillander, J., K. Hagberg, L. Hagberg, and R. Branemark, Osseointegrated Titanium Implants for Limb Prostheses Attachments: Infectious Complications. Clinical Orthopaedic Related Research, 2010. 468(10): p. 2781-2788

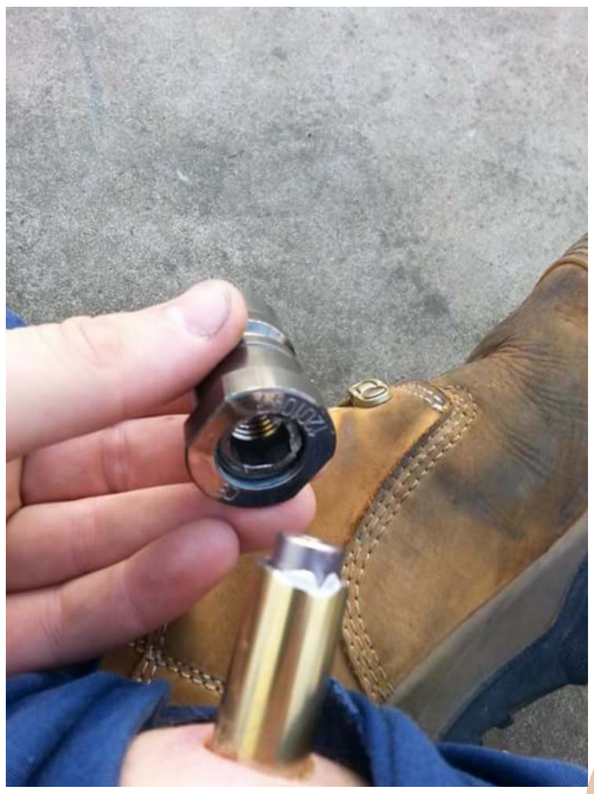
[2] Branemark, R., O. Berlin, K. Hagberg, P. Bergh, B. Gunterberg, and B. Rydevik, A novel osseointegrated percutaneous prosthetic system for the treatment of patients with transfemoral amputation: A prospective study of 51 patients. Bone Joint J, 2014. 96(1): p. 106-113.

Safety

Infections

Breakage

High-impact activities / Falls



Source: Facebook accessed 12/04/2016

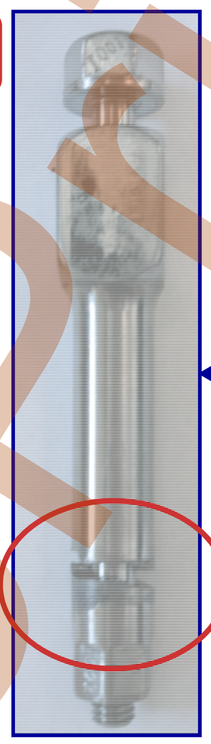
Source: Facebook accessed 21/11/2015

Safety

Infections

Breakage

High-impact activities / Falls



Activity of daily living

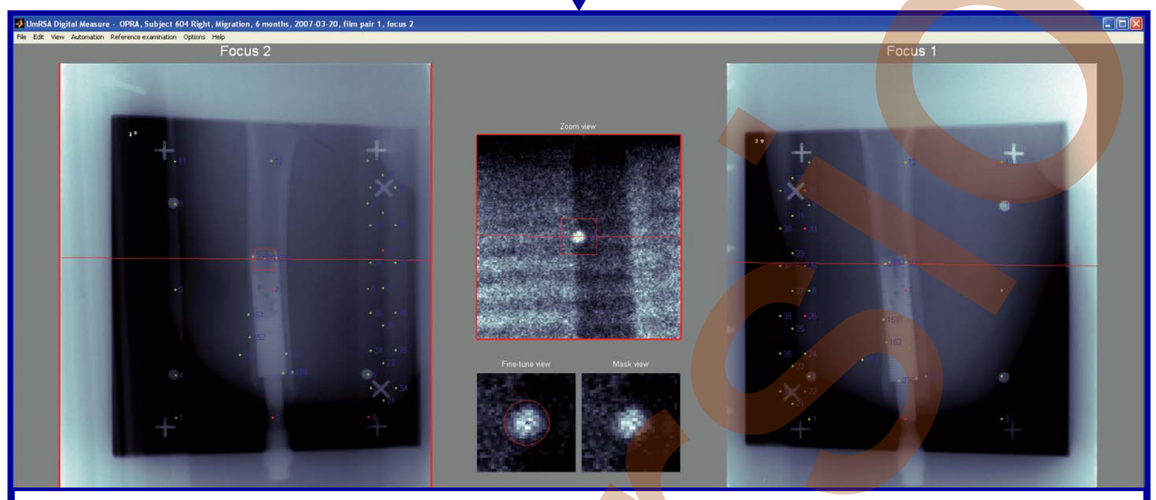
Thompson M. Mechanical analysis of osseointegrated transfemoral implant systems. 2009. Master Thesis. Queen's University Kingston, Ontario, Canada

Safety

- Infections
- Breakage
- **Loosening**

Titel RSA and radiographic

N=55



1, 2, 5, 7, 10 years post-op

Strong bonding

Nebergall, A., C. Bragdon, A. Antonellis, J. Kärrholm, R. Brånemark, and H. Malchau, Stable fixation of an osseointegated implant system for above-the-knee amputees. Acta Orthopaedica, 2012. 83(2): p. 121-128

Safety

- Infections
- Breakage
- Loosening
- **Factures**

xxx

xxx

Overview

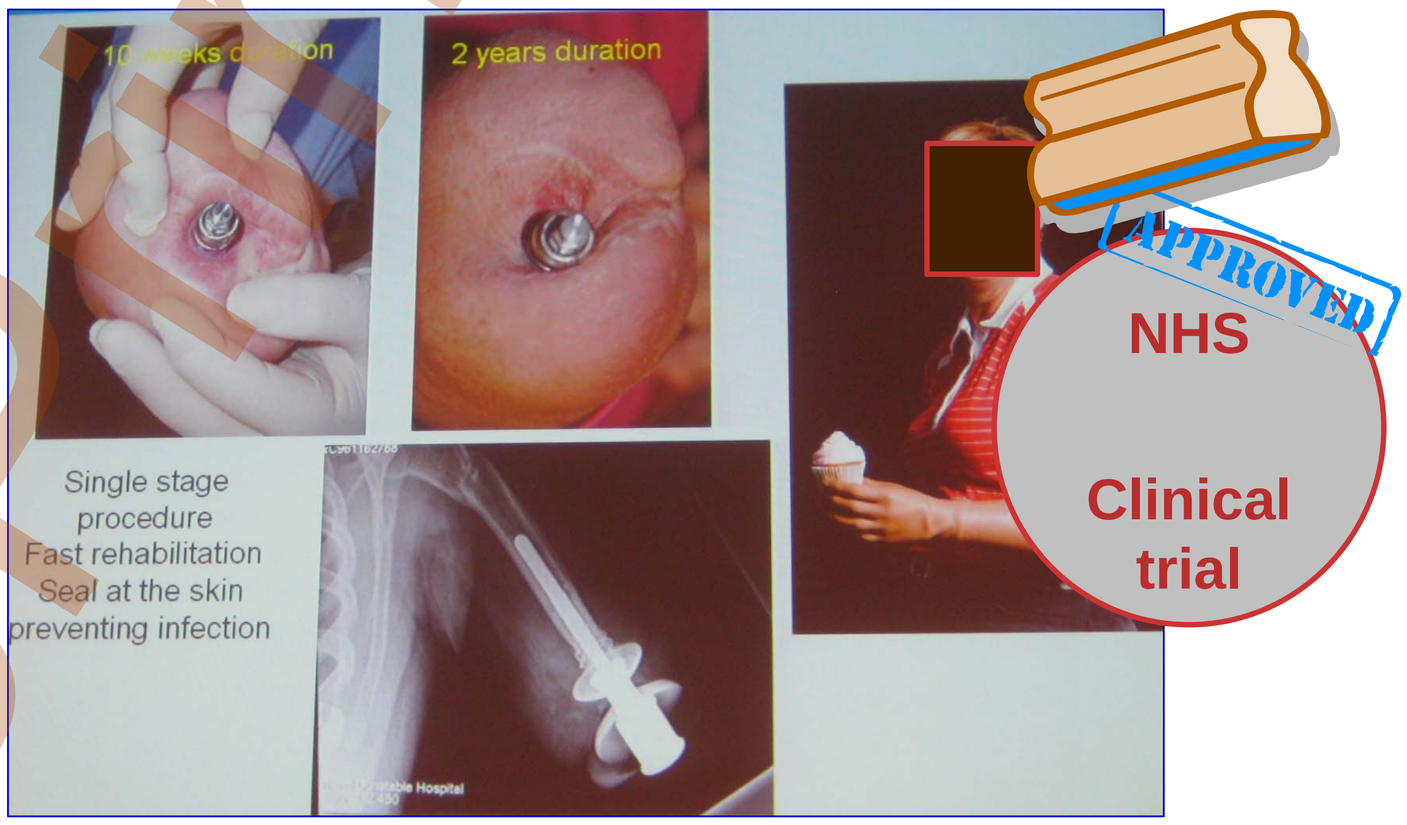
Bone-anchored prostheses from rehabilitation and beyond: is what you see is what you get?

Future developments

Future developments

Fixation

ITAP, Stanmore Implant, UK



Kang, N.V., C. Pendegrass, L. Marks, and G. Blunn, Osseocutaneous integration of an intraosseous transcutaneous amputation prosthesis implant used for reconstruction of a transhumeral amputee: Case report. The Journal of Hand Surgery, 2010. 35(7): p. 1130-1134.

Future developments

Fixation

University of Utah - Orthopaedics

Orthotics/Prosthetics

Researcher announces plans for FDA study of osseointegrated implants

September 24, 2013

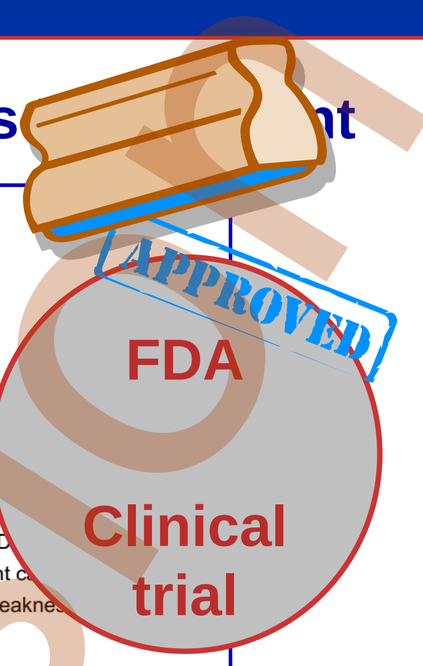
ORLANDO, Fla. — A Food and Drug Administration early feasibility study is expected to begin next year to t implants on humans, according to the presenter of the Keynote Address here at the O&P World Congress.

Roy Bloebaum, PhD, research professor at the University of Utah School of Medicine and co-director of the D Veterans Affairs Bone and Joint Research Lab in Salt Lake City, said a percutaneous, osseointegrated implant c socket complications, such as pain, discomfort, skin breakdown, pressure sores, phantom pain and muscle weakne improve mobility, comfort and the ability to quickly don and doff a prostheses.

Bloebaum and his colleagues have successfully implanted osseointegrated devices in sheep models, and they except to begin implanting the devices on human participants in April 2014.

"We want to inhibit periprosthetic infections, and we want to get successful load bearing," he said.

The study, collaboration between the University of Utah, Walter Reed National Military Medical Center and Brooke Army Medical Center, will include 10 transfemoral amputee participants. The evaluation process will include psychological and social prescreening tests and pre-implant and post-implant assessments, as well as a two-stage implementation procedure. Patients will then undergo follow-up testing for a minimum of 12 months, and two independent review boards will monitor the study.



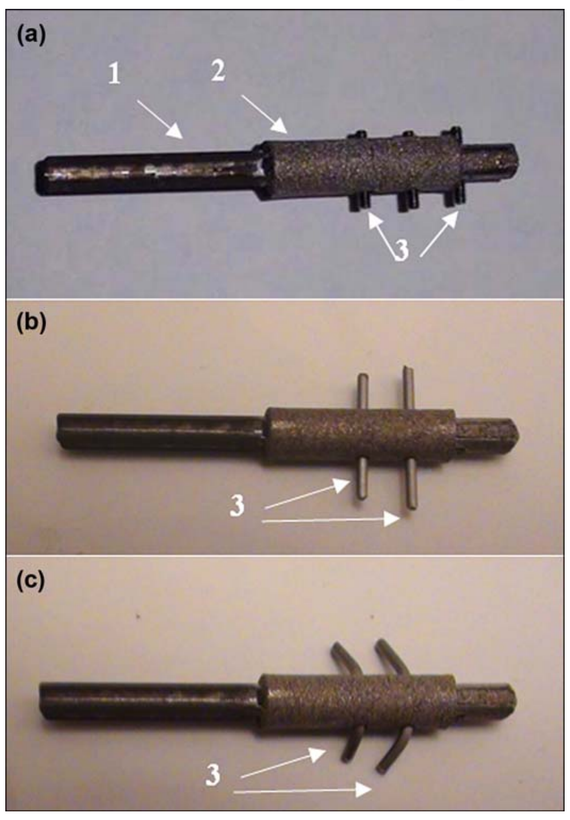
Roy Blobaum

http://www.healio.com/orthotics-prosthetics/prosthetics/news/online/%7Bbf5a0e16-eb8c-4e89-aa8b-0e2941bc31fb%7D/researcher-announces-plans-for-fda-study-of-osseointegrated-implants

Future developments

Fixation

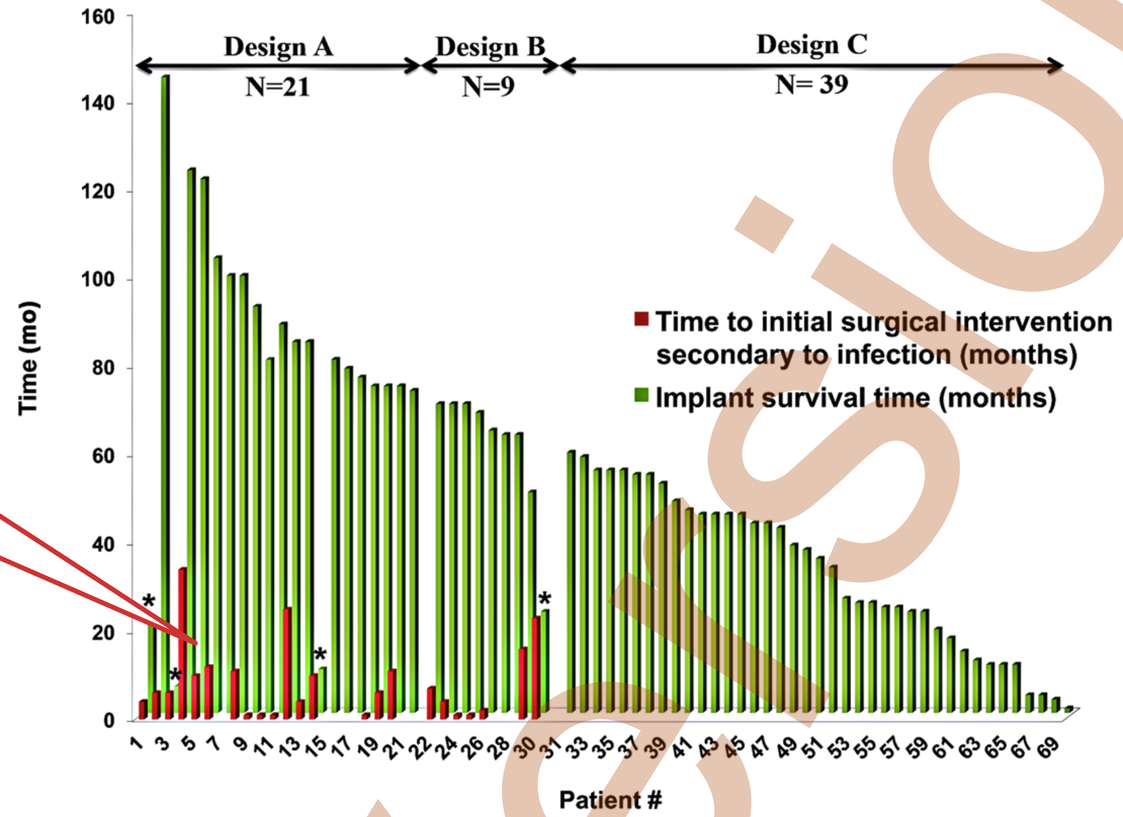
Tuft University



Pitkin, M., C. Cassidy, R. Muppavarapu, R. J, M. Shevtsov, O. Galibin, and S. Rousselle, New method of fixation of in-bone implanted prosthesis. J Rehabil Res Dev, 2013. 50(5): p. 709-722.

Future developments

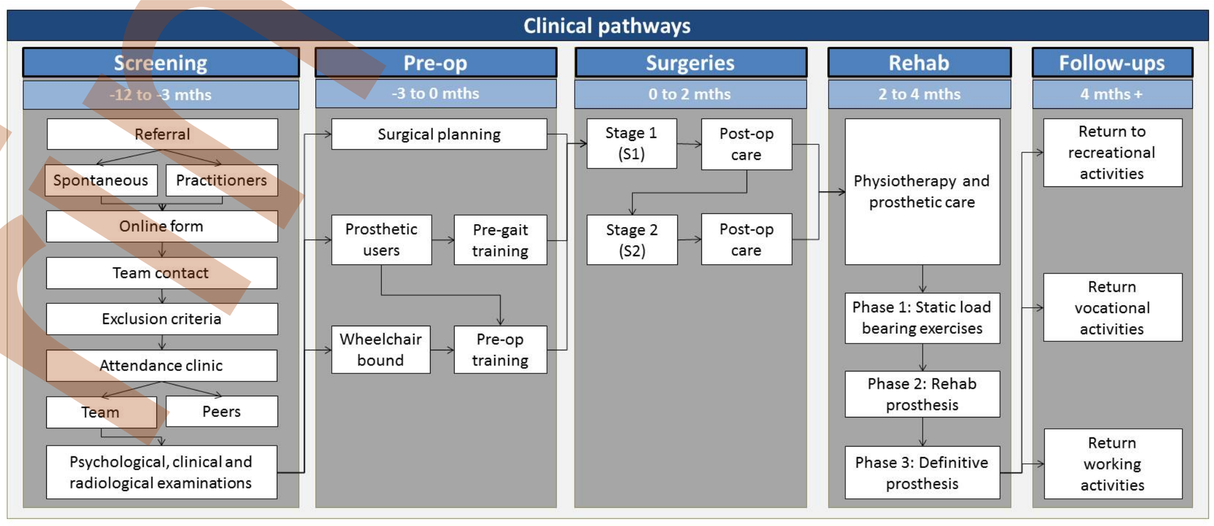
Fixation



Juhnke, D.-L., J.P. Beck, S. Jeyapalina, and H.H. Aschoff, Fifteen years of experience with Integral-Leg-Prosthesis: Cohort study of artificial limb attachment system. Journal of Rehabilitation Research and Development, 2015. 52(4): p. 407-420.

Future developments

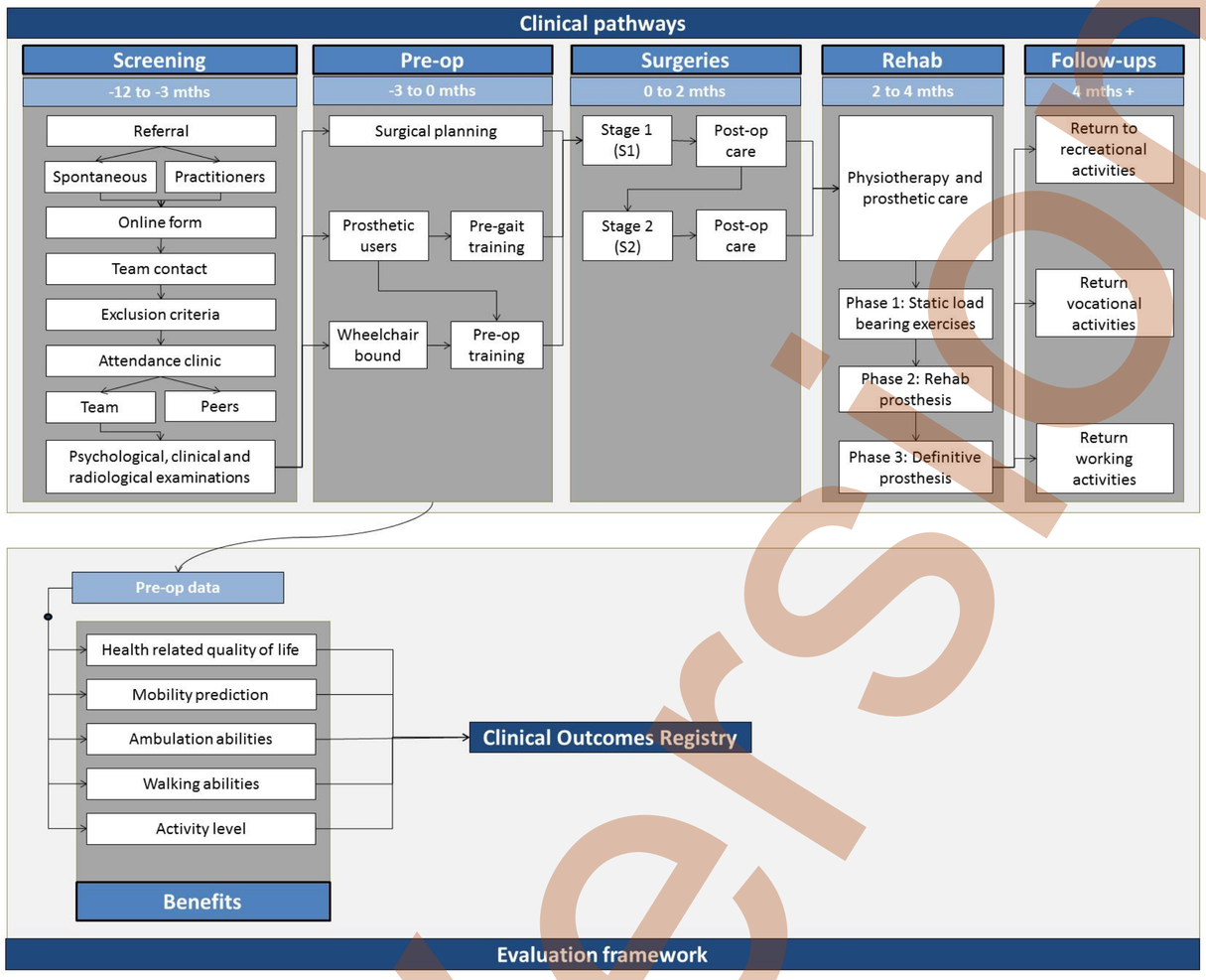
Fixation



Frossard L. Evaluation framework to assess benefits and harms of bone-anchored prosthesis. OSOS. 2015

Future developments

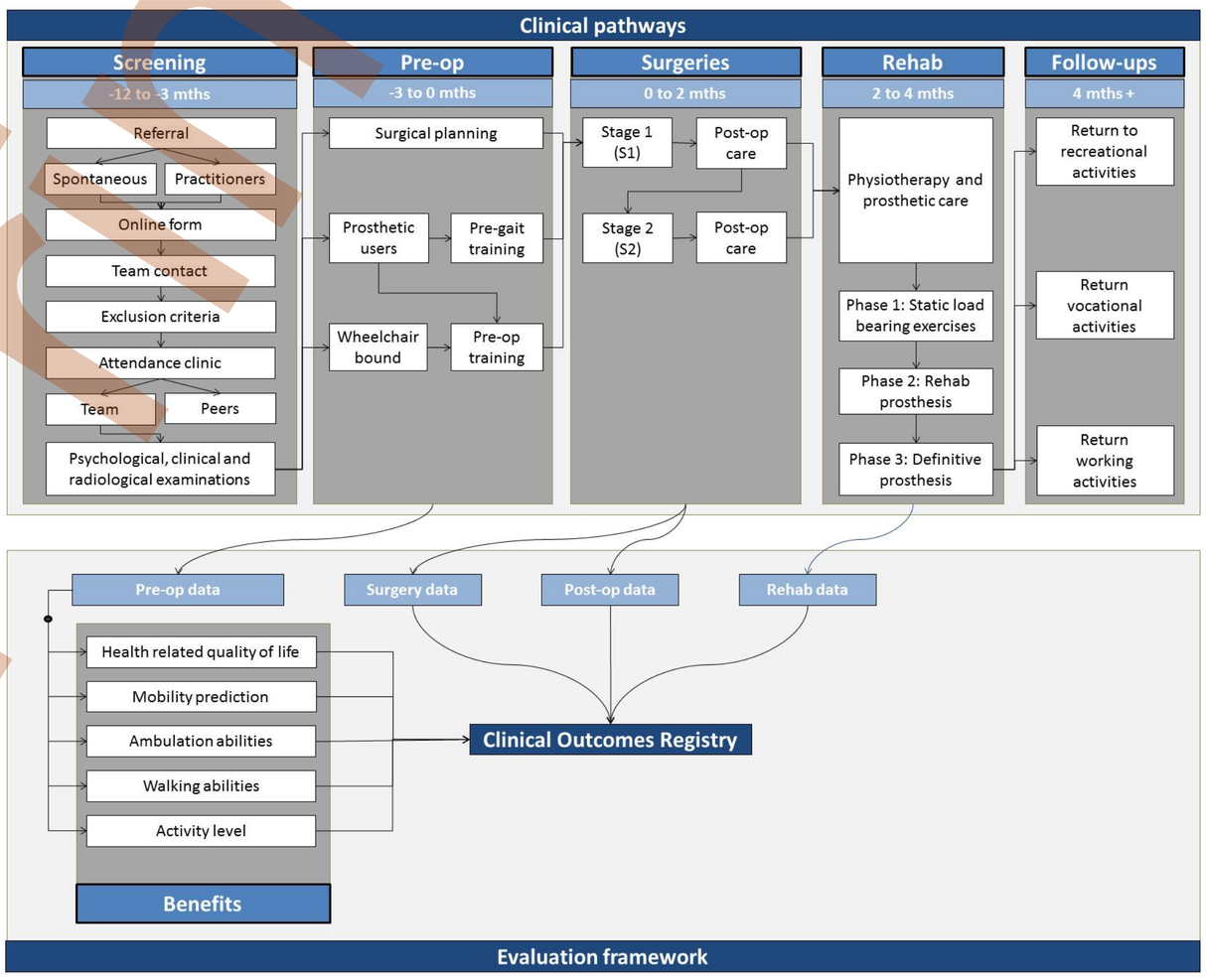
Fixation



Frossard L. Evaluation framework to assess benefits and harms of bone-anchored prosthesis. OSOS. 2015

Future developments

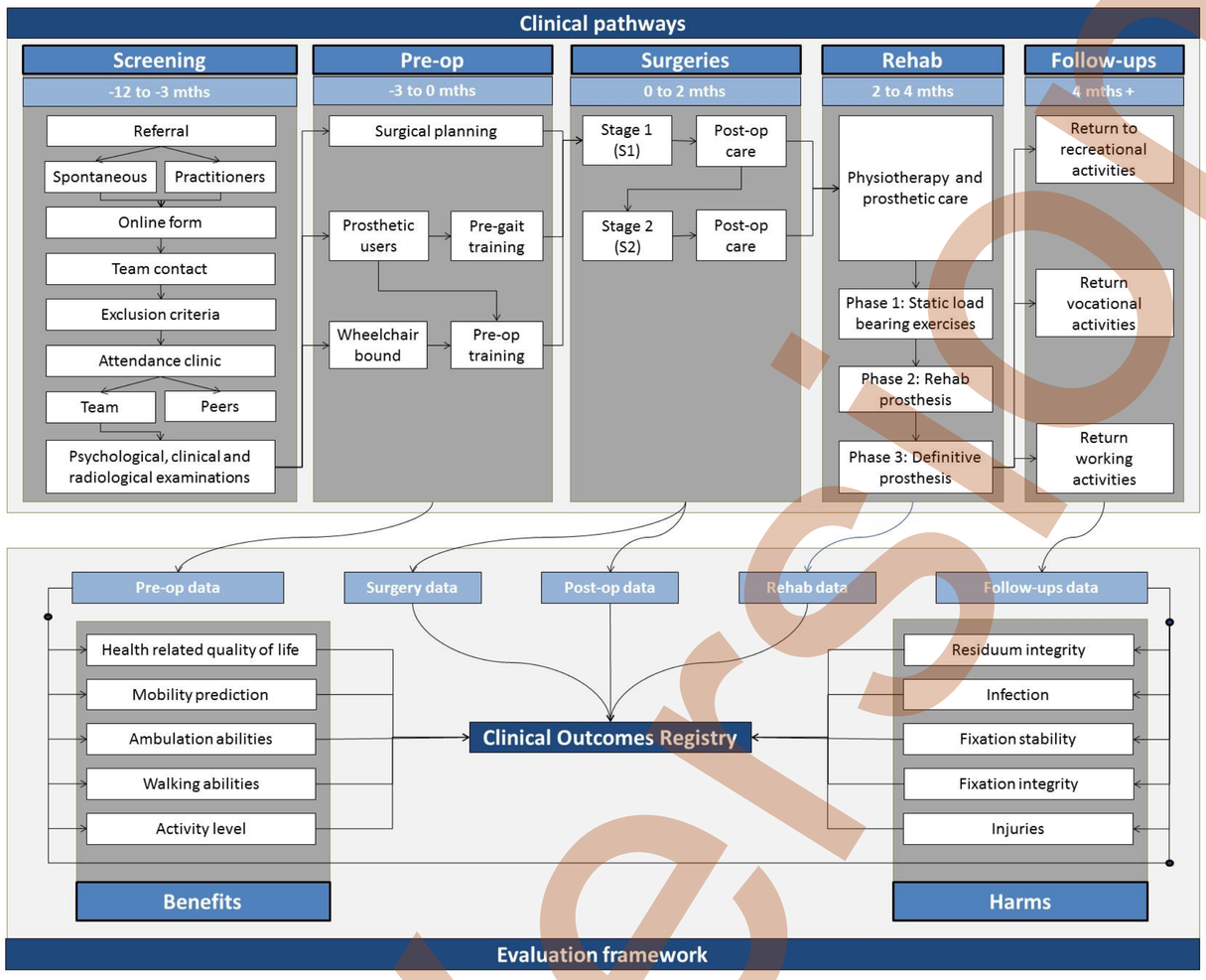
Fixation



Frossard L. Evaluation framework to assess benefits and harms of bone-anchored prosthesis. OSOS. 2015

Future developments

Fixation



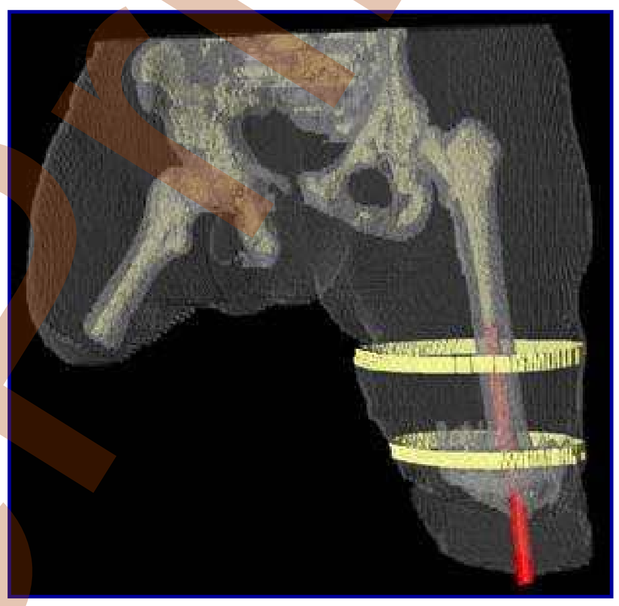
Frossard L. Evaluation framework to assess benefits and harms of bone-anchored prosthesis. OSOS. 2015

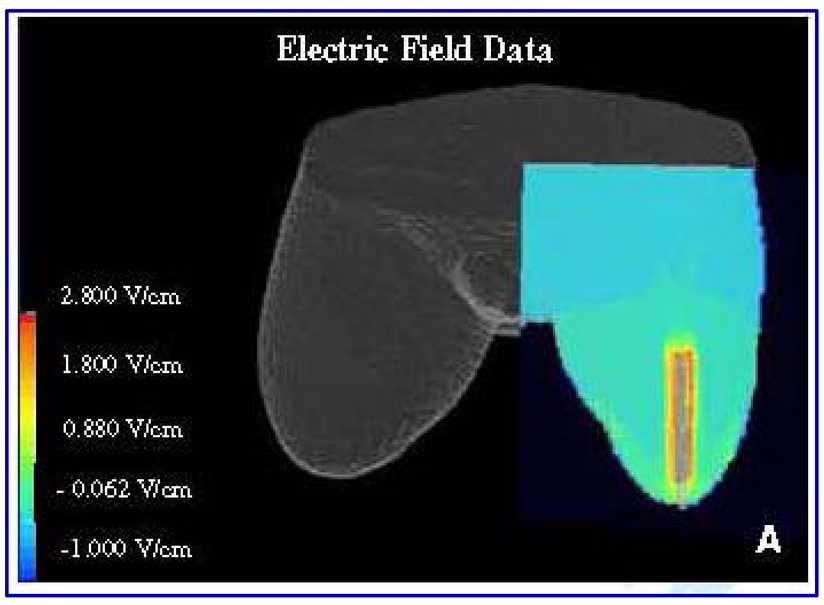
Future developments

Fixation

Focus

Electrical field for osseointegration





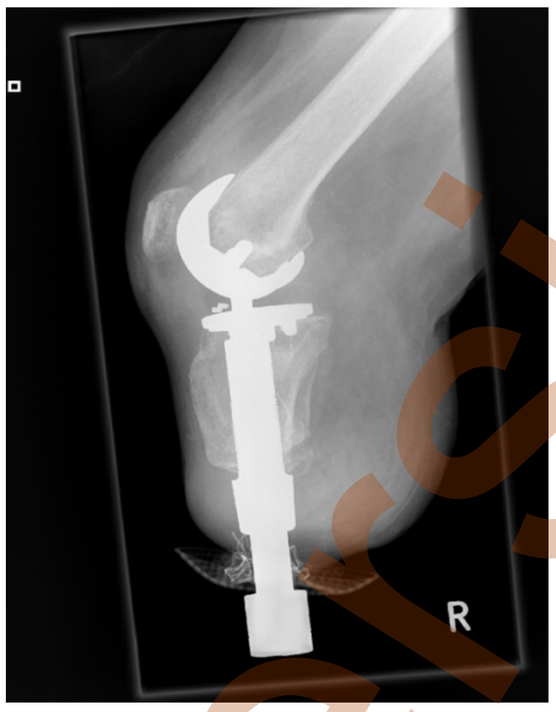
Isaacson, B.M., J.G. Stinstra, R.D. Bloebaum, P.F. Pasquina, and R.S. MacLeod, Establishing multiscale models for simulating whole limb estimates of electric fields for osseointegrated implants. IEEE Trans Biomed Eng, 2011. 58(10): p. 2991-4.

Future developments

Fixation

Focus

Surgical methods



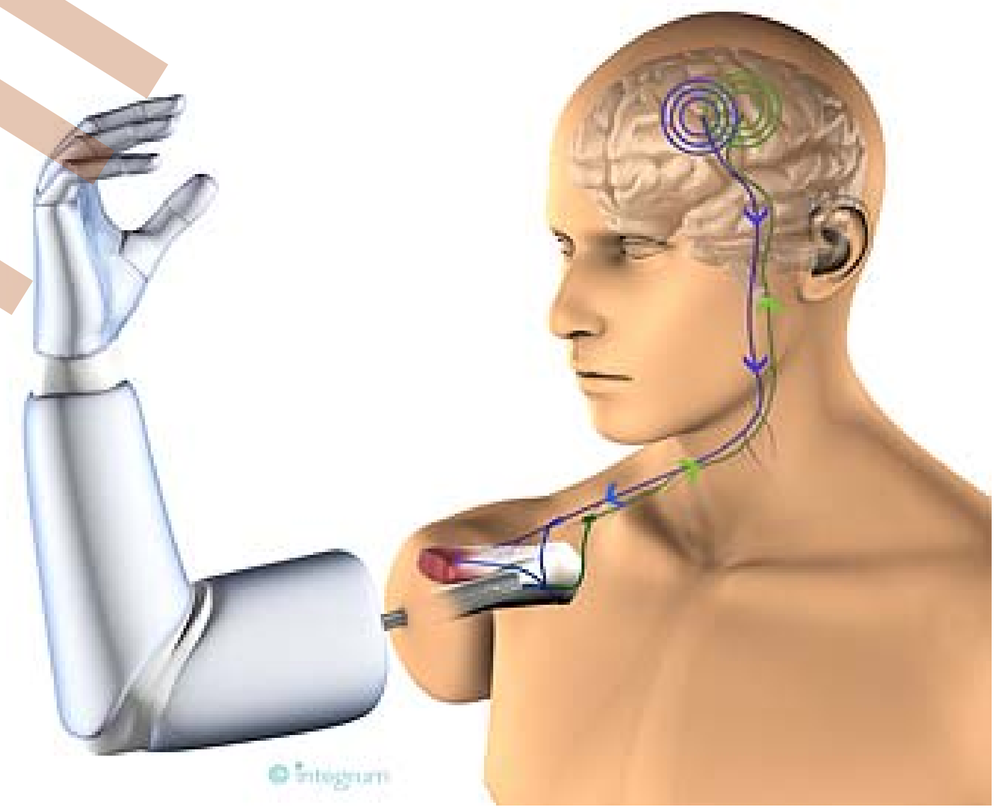
Khemka A, Frossard L, Lord S, Bosley B, Al Muderis M. Transcutaneous bone-anchoring prosthesis with total knee replacement. Acta Orthopedica. 2015. In press.

Future developments

Fixation

Focus

Neuromuscular control of prosthesis



http://www.chalmers.se/en/news/Pages/Thought-controlled-prosthesis-is-changing-the-lives-of-amputees.aspx

Future developments

Fixation

Focus

Challenges

Accessible to population with diabetes

ORIGINAL ARTICLE

Estimating the Prevalence of Limb Loss in the United States: 2005 to 2050

Kathryn Ziegler-Graham, PhD, Ellen J. MacKenzie, PhD, Patti L. Ephraim, MPH, Thomas G. Travison, PhD, Ron Brookmeyer, PhD

Conclusions: One in 190 Americans is currently living with the loss of a limb. Unchecked, this number may double by the year 2050.

K. Ziegler-Graham, E. J. MacKenzie, P. L. Ephraim, T. G. Travison, and R. Brookmeyer, "Estimating the prevalence of limb loss in the United States: 2005 to 2050," Arch Phys Med Rehabil, vol. 89, pp. 422-9, Mar 2008.

Future developments

Fixation

Focus

Challenges

Primary intervention

http://www.smh.com.au/news/national/lplate-collision-kills-policewoman/2008/04/20/1208629736691.html

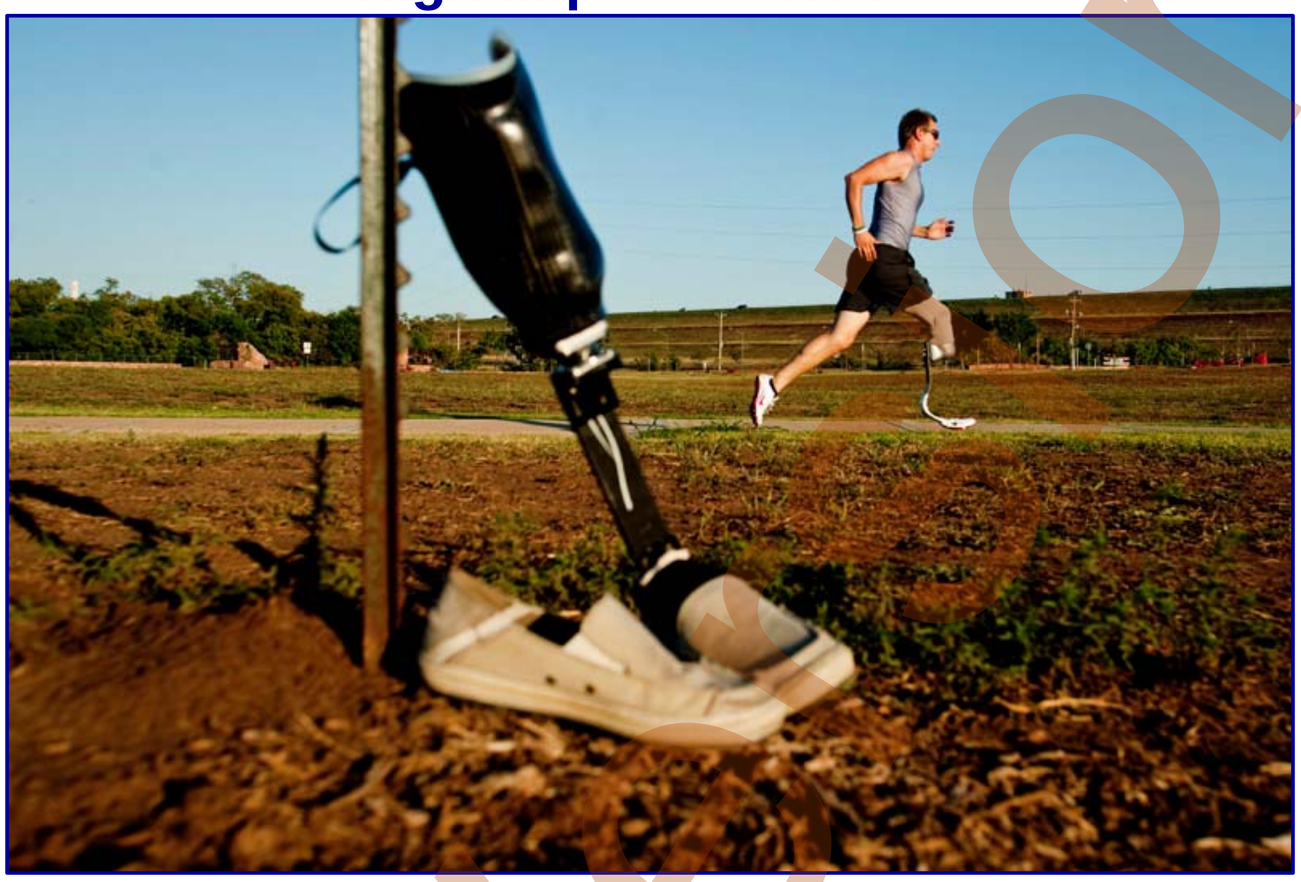
Future developments

Fixation

Focus

Challenges

High impact activities



http://www.tulsaworld.com/

Future developments

Fixation

Focus

Challenges

Pediatric applications

26 Quantum Leap: Transitioning from Pediatric to Adult Care

By Miki Fairley

http://online.publicationprinters.com/launch.aspx?eid=202f0de3-6dd9-4208-8677-4c273a37b5d3

Future developments

Fixation

Focus

Challenges

Accessible after natural disasters

http://www.msf.org.uk/teaching-resources-level-geography

Future developments

Fixation

Focus

Challenges

Accessible to low income countries

http://projecthopeinthefield.blogspot.ca/2010_04_01_archive.html

Conclusions

Bone-anchored prostheses from rehabilitation and beyond: is what you see is what you get?

Laurent Frossard
Researcher | Leader | Educator | Entrepreneur

Adj/Prof Laurent Frossard

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University of the Sunshine Coast, Australia

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Rehabilitation Medicine Society of Australia and New Zealand

1st Annual Scientific Meeting

19 October 2016

Crown Promenade, Melbourne

Laurent Frossard

Researcher | Leader | Educator | Entrepreneur

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Google+

www.plus.google.com/#113083134851353167716/about

Facebook

www.facebook.com/YourResearchProject